UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

SAN FRANCISCO DIVISION

COREPHOTONICS, LTD., Plaintiff, v. APPLE INC., Defendant.	Case No. 3:17-cv-06457-JD (lead case) Case No. 5:18-cv-02555-JD **DECLARATION OF FRÉDO DURAND IN SUPPORT OF APPLE INC.'S PROPOSED CLAIM CONSTRUCTIONS**

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I, Frédo Durand, declare and state as follows:

1. I submit this declaration in support of claim construction positions regarding certain claim terms recited in U.S. Patent No. 9,185,291 ("'291 Patent").

I. QUALIFICATIONS AND EXPERIENCE

2. My qualifications and professional experience are described in my Curriculum Vitae, a copy of which is attached hereto. The following is a brief summary of my relevant qualifications and professional experience.

3. I earned my Bachelor's degree in Math and Computer Science from École Normale Superieure of Paris, France in 1993, Master of Science degree in Computer Science from Grenoble Institute of Technology, Grenoble, France in 1994, and Ph.D. degree in Computer Science from Joseph Fourier University, Grenoble, France in 1999. My doctoral thesis focused on 3D visibility and lighting simulation.

4. For more than 25 years, I have been developing professional and academic experience in the field of imaging systems, including integration of optics, sensors, and digital processing in imaging systems. My research interests span most aspects of picture generation and creation, and one of the major themes of my research has been directed to computational photography, which combines expertise in optics design and image processing.

5. I am a tenured full Professor in the Electrical Engineering and Computer Science Department of the Massachusetts Institute of Technology, and a member of the Computer Science and Artificial Intelligence Laboratory.

6. As a professor, I teach in the area of computational photography. In the courses of Computational Photography, I teach principles of computational photography through a series of hands on projects, including applications of computational photography in high-dynamic range photography, photomontage, panoramas, image resampling, foreground extraction, Bayer sensor demosaicing, optical aberration correction, background defocusing, and morphing.

7. I have authored and co-authored over two hundred journal publications, conference proceedings, technical papers, and technical presentations in the area of imaging system technologies, including optics design, image processing, and computational photography.

8. In 2004, I received an inaugural Eurographics Young Researcher Award. I received a National Science Foundation (NSF) Faculty Early Career Development (CAREER) award in 2005. The NSF CAREER award is to support my research project "Transient Signal Processing for Realistic Imagery," which is NSF's most prestigious award in support of early-career faculty who has the potential to serve as academic role models in research and education and to lead advances in the mission of their department or organization. The goal of this project is to characterize light transport from a signal-processing perspective with applications to image synthesis and material-appearance acquisition. I received an inaugural Microsoft Research New Faculty Fellowship in 2005, a Sloan fellowship in 2006, a Spira award for distinguished teaching in 2007. I received Association for Computing Machinery's (ACM's) Special Interest Group on Computer Graphics and Interactive Techniques (SIGGRAPH) Computer Graphics Achievement Award in 2016, which is given by the organization each year to recognize an individual for an outstanding achievement in computer graphics and interactive techniques. I became an ACM fellow in 2016, which is ACM's most prestigious member grade that recognizes the top 1% of ACM members for their outstanding accomplishments in computing and information technology and/or outstanding service to ACM and the larger computing community.

9. My involvement in the research community extends to several organizations, journals, and conferences. Over the years, I have organized and served in the Program Committee of a variety of conferences, including IEEE International Conference on Computational Photography, Symposium on Computational Photography and Video, ACM SIGGRAPH, Eurographics Symposium on Rendering (EGSR), Graphics Interface, Eurographics, Non-Photorealistic Animation and Rendering (NPAR), Symposium on Point-Based Rendering, ACM Transactions on Graphics, Foundations and Trends in Computer Graphics and Computer Vision. I was a Member of the advisory board of Image and Meaning 2, an interdisciplinary conference on scientific illustration and education.

10. A list of my publications and patents is contained in my CV.

11. I have worked on many research projects related to fusion technologies. My work in image fusion includes work on fusing two photos: one taken with the available light only, and

one taken with flash. This work was published in the paper, Eisemann and Durand, "Flash Photography Enhancement via Intrinsic Relighting," ACM Transactions on Graphics, (TOG) 23, no 3 (2004) 673-678[1] (listing key words about the article including "Computational photography" and "image fusion"). In this work, we used a bilateral filter to decompose the images into detail and large scale. We then reconstructed a fused image using the large scale information from the photo with available lighting, and the detailed information from the photo taken with flash. *Id.*, Abstract. This article is well known for its teaching of using bilateral filters to decompose images into detail and large scale and for applying the bilateral filter to an image while using a second image to guide the filtering (which we call "cross bilateral filter"), and has been cited by over 842 other publications according to Google Scholar.

12. Other research work on fusing images was published in Hasinoff , Kiriakos, Durand, and Freeman, "Time-constrained photography," 2009 IEEE 12th International Conference on Computer Vision, pp. 333-340. IEEE, 2009.[2] In this publication, we describe research showing that the capture of multiple photos of the same scene at different focus settings and combining them to create an "all-in-focus" image with just the in-focus portions of each image. Using this method, our research suggests that splitting a camera's exposure budget (the amount of time it has to take each photo) across several photos can provide a significant quality advantage.

II. INTRODUCTION

13. I have been retained by counsel for Apple Inc. ("Apple") as a technical expert in connection with the litigation identified above. Specifically, I have been asked to provide my opinions regarding the state of the art and the technology of the '291 Patent as well as how those of ordinary skill in the art of the '291 patent at the time would have understood certain terms in the claims of the '291 Patent at the time of the patent, around 2013. My opinions are based on my education, knowledge, experience in the field of the '291 Patent, and the intrinsic and extrinsic

[1] Available at https://scholar.google.com/citations?view_op=view_citation&citation_for_view=NJ9c4ygAAAAJ:qjMakFHDy7sC

[2] Available at: https://people.csail.mit.edu/hasinoff/timecon/

evidence to the ’291 patent that I have reviewed.

14. I have been asked to opine on the correct meaning of the following claim terms in the context of the ‘291 patent:

- “Wide” [lens, field of view (FOV), sensor, image signal processor, imaging section, image data]
- “Tele” [lens, field of view (FOV), sensor, image signal processor, imaging section, image data]
- “fused”/”fusion”
- “fused output image”/”without fusion … output images”
- “fused image of the object or scene from a particular point of view”
- “image data”

15. Compensation for my work in this matter is based on my standard consulting hourly rate of $600 per hour. This compensation is not contingent on the outcome of this matter, nor is it contingent on the specifics of my testimony. I have no personal or financial stake, nor any interest in the outcome of the present proceeding.

III. LEVEL OF ORDINARY SKILL IN THE ART

16. I understand that the level of ordinary skill may be reflected by the prior art of record, and that a Person of Ordinary Skill in The Art (“POSITA”) to which the claimed subject matter pertains would have the capability of understanding the scientific and engineering principles applicable to the pertinent art. I understand that a POSITA has ordinary creativity, and is not an automaton.

17. I understand that there are multiple factors relevant to determining the level of ordinary skill in the pertinent art, including (1) the levels of education and experience of persons working in the field at the time of the invention; (2) the sophistication of the technology; (3) the types of problems encountered in the field; and (4) the prior art solutions to those problems.

A. Level of Ordinary Skill in the Art for the ’291 Patent

18. I am familiar with imaging system art pertinent to the ’291 Patent. I am also aware of the state of the art at the time the application resulting in the ’291 Patent was filed. I have been

informed by counsel that the earliest claimed priority date for the ’291 Patent is June 13, 2013, although any given claim of the ’291 Patent may or may not be entitled to the earliest claimed date.

19. Based on the technologies disclosed in the ’291 Patent, I believe that a POSITA would include someone who had, as of the claimed priority date of the ’291 Patent, a bachelor’s or the equivalent degree in electrical and/or computer engineering or a related field and 2-3 years of experience in imaging systems including optics and image processing. In addition, I recognize that someone with less formal education but more experience, or more formal education but less experience could have also met the relevant standard for a POSITA. I believe that I am at least a POSITA and, furthermore, I have supervised students and engineers who were also POSITAs. Accordingly, I believe that I am qualified to opine from the perspective of a POSITA regarding the ’291 Patent.

20. For purposes of this Declaration, unless otherwise noted, my opinions and statements regarding the ’291 Patent, such as those regarding the understanding of a POSITA (and specifically related to the references I consulted herein), reflect the knowledge that existed in the art before the earliest claimed priority date of the ’291 Patent.

21. Corephotonics’s expert Dr. Hart opines that a POSITA for the ‘291 patent would be “would be a person with a bachelor’s degree or equivalent in computer engineering, electrical engineering, or a related field, with approximately 2–3 years of experience in imaging systems.” Hart Decl. (Dkt. 148-11), ¶ 13. This is very similar to my the opinion on the background of a POSITA. In my opinion, however, a POSITA for the ‘291 patent must have experience in optics and image processing, as I note above.

B. Level of Ordinary Skill in the Art for the ’712 Patent

22. Corephotonics’s expert opines that a POSITA for the ’712 patent “would be a person with a bachelor’s [sic] approximately 2–3 years of experience in imaging systems or equivalent in computer engineering, optical engineering, or related field, with at least 2 years of experience working with optical designs.” Hart Decl. (Dkt. 148-11), ¶ 14. I disagree. In my opinion, the ’712 patent is not intended for those, like me, who merely work with optical designs, but for those who perform lens design, which is a highly technical field in its own right. I am not a lens designer and

Dr. Hart does not appear to be either. Therefore, I do not provide further opinions regarding the ’712 patent.

23. I note that in *inter partes* review proceedings for the U.S. Patent No. 10,254,479, I provided opinions in support of Apple’s petition and Dr. Hart provided opinions in support of Corephotonics’ response. The ‘479 patent included some limitations related to optics, and for those, I relied on the opinion of Dr. Jose Sasian, an expert in lens design. Dr. Hart likewise relied on the opinion of Dr. Moore, a lens design expert, and did not claim to be an expert in lens design or qualified to give opinions on a lens design patent. *E.g.*, Ex. L, (IPR2020-00905 (‘479 patent), Hart Decl.), ¶¶ 35, 50, 89, 90-95.

IV. MATERIALS CONSIDERED

24. In preparing this declaration, I have reviewed and considered all of the materials cited below.

V. RELEVANT LEGAL STANDARDS

25. I am not an attorney. In preparing and expressing my opinions and considering the subject matter of the ’291 Patent, I am relying on certain legal principles explained to me by counsel.

26. It is my understanding that in order to properly evaluate the ’291 Patent, the terms of the claims must first be interpreted. It is my understanding that the claim terms are given their ordinary and accustomed meaning as would be understood by one of ordinary skill in the art, unless the inventor has set forth a special meaning for a term. In order to construe the following claim terms, I have reviewed the entirety of the ’291 Patent, as well as its prosecution history.

27. I understand that patent claims are construed from the viewpoint of one of ordinary skill in the art of the patent at the time of the alleged invention. I also understand that the most important evidence to consider in construing the claims is the “intrinsic” record, which I understand includes the claim language, the patent specification, and the prosecution history.

28. I further understand that the person of ordinary skill in the art must read the claim terms in the context of the claim itself, as well as in the context of the entire patent specification. I understand that in the specification and prosecution history, the patentee may act as a lexicographer

and specifically define a claim term in a way that differs from the plain and ordinary meaning. I understand that the prosecution history of the patent is a record of the proceedings before the U.S. Patent and Trademark Office, and may contain explicit representations, statements or definitions made during prosecution that affect the scope of the patent claims. I understand that an applicant may, during the course of prosecuting the patent application, limit the scope of the claims to overcome prior art or to overcome an examiner's rejection

29. I further understand that claim terms are presumed to have the same meaning in all claims, unless there is any evidence to the contrary.

30. I further understand that under the doctrine of claim differentiation, it is presumed that no two claims in the same patent cover the same scope. Each claim is presumed to be different in scope and meaning from other claims.

31. In interpreting the meaning of the claim language, I understand that the person of ordinary skill in the art may also consider "extrinsic" evidence, including expert testimony, inventor testimony, dictionaries, technical treatises, other patents, and scholarly publications. I understand this evidence is considered to ensure that a claim is construed in a way that is consistent with the understanding of those of ordinary skill in the art at the time of the claimed invention. This can be useful for technical terms whose meaning may differ from their ordinary English meaning. I understand that extrinsic evidence may not be relied on if it contradicts or varies the meaning of claim language provided by the intrinsic evidence, particularly if the applicant has explicitly defined a term in the intrinsic record.

32. I further understand that statements in the specification that expressly or implicitly state that specific subject matter is outside the scope of the invention can operate as a disclaimer of claim scope. I have also been informed that when the specification makes clear that the invention does not include a particular feature, that feature is deemed to be outside the reach of the claims of the patent, even though the language of the claims, read without reference to the specification, might be considered broad enough to encompass the feature in question. I further understand that, although any description of "the present invention" in the specification does not automatically limit the claims, when a patent describes the features of the "present invention" as a whole, this

description can limit the scope of the invention. In addition, where the general summary or description of the invention describes a feature of the invention, and criticizes other products or systems that lack the same feature, I understand that this may also operate as a disavowal of scope

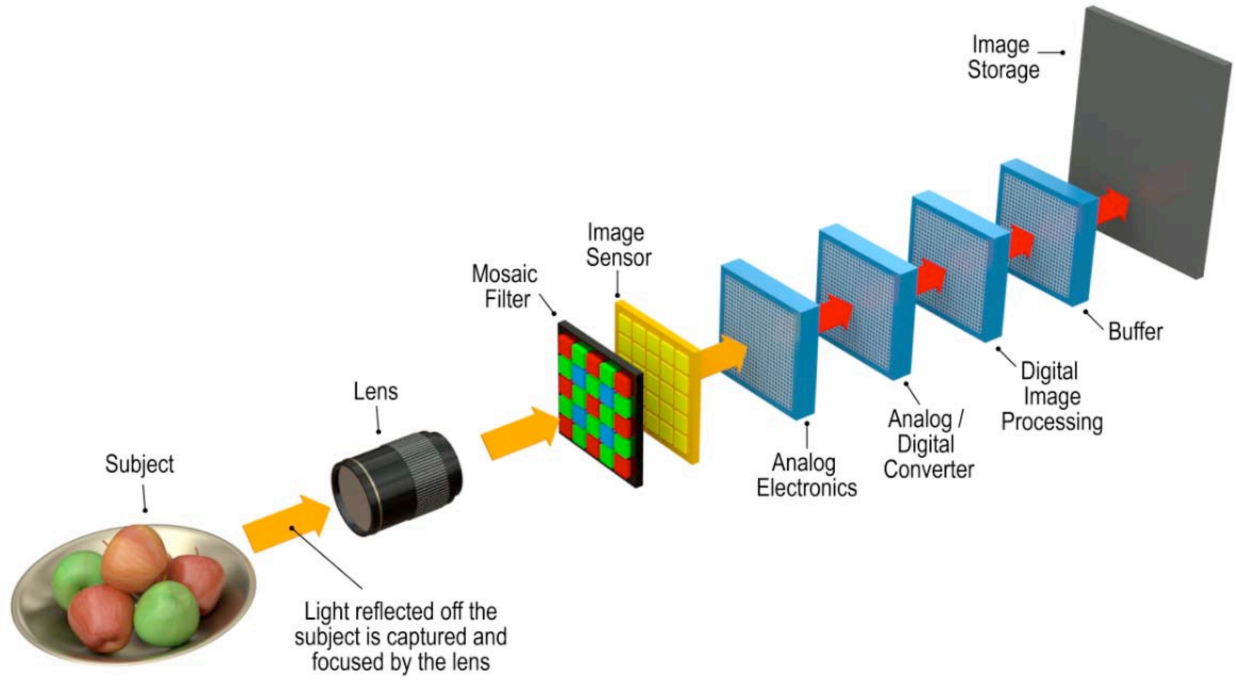
VI. TECHNOLOGY BACKGROUND

33. In this section, I provide a technology background regarding the state of the art at the time of filing of the ‘’291 Patent.

34. This declaration is on the subject of photographic imaging systems, and I note that Dr. Hart agrees. (*See* Hart CC Decl. (Dkt. 148_11), ¶ 11.) Photography is 200 years old and digital imaging systems have been in commercial use for over 30 years. As such, much of the terminology used to describe these systems has long-standing and well understood meaning to a POSITA. In this section I will explain some of these basic concepts, using some excerpts from “Optics in Photography,” by Rudolf Kingslake (1992), a book I use to explain basic optics concepts relevant to photographic imaging systems.

A. Digital Camera Overview

35. The claims of the ‘291 Patent are directed to digital cameras. At a high level, the purpose of a camera it to capture an image and store that image in some medium, such as a memory card in a digital camera (or film in the case of a traditional camera). Below is a generalized figure depicting the basic structure of a digital camera.



36. As illustrated in Figure 1 above, generally in a digital camera, visible light reflected from the subject (a bowl of apples in Figure 1) enters the camera through a lens and is focused onto the image sensor. The image sensor outputs an analog image signal corresponding to the amount of light recorded at each picture element by the image sensor. The camera may then perform processing on the analog output signal of the image sensor. For example the analog signal can be amplified to ensure that the signal level is sufficient for further transmission or processing. After the analog signal processing, the signal is converted from an analog signal to a digital signal by an analog-to-digital ("A/D") converter. The digital signal may then be further processed by an ISP (Image Signal Processor) before it is stored or displayed.

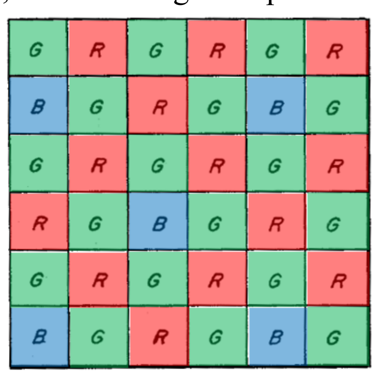
37. The image sensor senses the received light and converts the light into an electrical signal. Image sensors are made up of a matrix of photosensitive elements. The matrix divides the sensor into discrete spatial elements known as cells or picture elements, which is commonly abbreviated as "pixels" or "pels."

38. The electrical charge accumulated at each pixel is related to the number of photons received at the location of the pixel. This is also referred to as the light intensity, where more received photons means greater light intensity. The greater the light intensity, the greater the

accumulated charge, and hence the signal output from that pixel will be larger. The electrical signals from the pixels are typically in analog format.

39. The photosensitive material in an image sensor is not itself sensitive to color. It is typically sensitive to the entire visible spectrum and thus responds to all wavelengths of light that it receives in the visible spectrum. The signal output by an image sensor at each pixel represents the intensity of light measured at the pixel across all wavelengths of light. In the absence of any color filtering (as is the case with monochrome sensors) pixels will absorb all light across the visible spectrum and output a single value representing the amount of light received at the pixel. This single value at each pixel represents the light intensity or luminance at the pixel. These images are also known as grayscale or monochrome images.

40. In order to measure information about color at the image sensor, a color filter array is typically placed in front of the image sensor. Color filter arrays have been known since at least the 1970s with the issuance of U.S. Patent No. 3,971,065 ("Bayer") entitled "Color Imaging Array," to inventor Bryce Bayer and assignee Kodak. The Bayer patent disclosed an image sensor in which "a mosaic of selectively transmissive filers is superposed in registration with a solid state array having a broad range of light sensitivity . . . ." Bayer, at Abstract. That is, as explained above, the photosensitive imaging array of the image sensor is sensitive to a "broad range" of light wavelengths. A mosaic of color filters is used such that each cell (i.e., pixel) of the array is aligned with its own color filter and, accordingly, receives mostly that color light. The Bayer patent specifically disclosed, for example, the following example of a mosaic color filter:



Bayer, Figure 6 (edited with color). The individual color filters in the mosaic above are red, green, and blue, and arranged in an alternating pattern. They may also be arranged in other patterns.

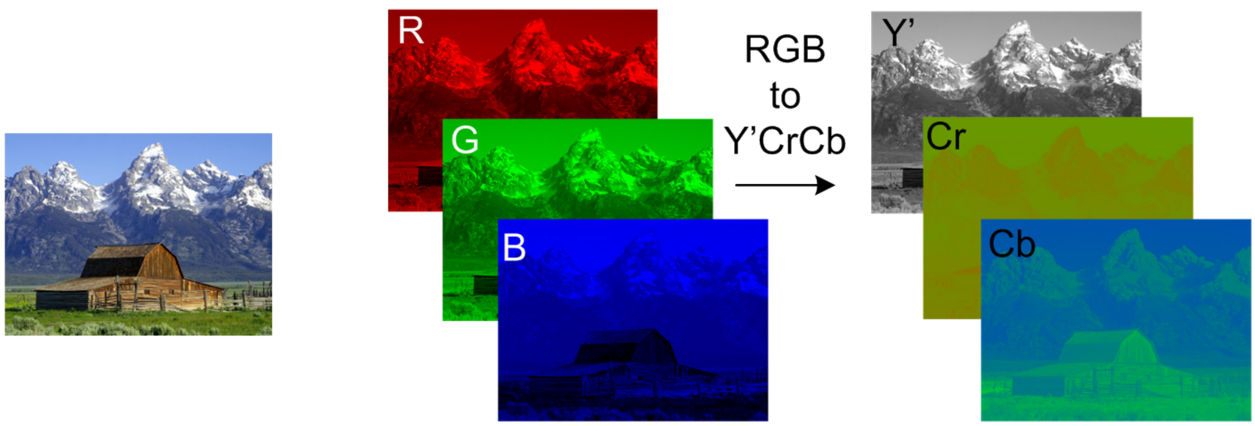
41. Each colored grid element of the mosaic filter corresponds to one pixel of the image sensor. The colored grid element allows only a relatively narrow range of wavelengths relating to its respective color to pass through to the image sensor cell. For example, in the above figure, the red-colored grid elements of the mosaic filter allow light with wavelengths in primarily the red region of the visible spectrum to pass through to the corresponding cell of the image sensor. That particular cell, therefore, will measure the intensity of only the red light from the scene at that location. Likewise, the image sensor cells under the individual blue filters will be sensitive to only blue light, and the image sensor cells under the individual green filters will be sensitive to only green light.

42. In order to reconstruct a color image from the output of a "color" image sensor with a mosaic color filter, it is necessary to process the output signal of the image sensor. Each pixel of the image sensor outputs a single value representing the intensity of light at that particular pixel, but the intensity value does not itself convey the color at that pixel. The process of reconstructing a color image from the output signal of an image sensor coated with a mosaic color filter array requires knowledge as to what region of the color spectrum is represented by the signal value from each pixel. In addition, the missing values representing the other regions of the color spectrum for each pixel must be interpolated; this process is commonly referred to as demosaicing or color interpolation.

43. Red, green, and blue are common color elements in a mosaic color filter because those three colors can adequately capture and reproduce most colors when mixed in varying degrees. A color space specified using amounts of red, green and blue light is known as an RGB color space, and the most common one is called sRGB (for standard RGB). Images in digital photographs are often represented using the sRGB color space. When represented in an RGB color space, an image is also said to be comprised of red, green, and blue "channels." The red channel has the values that represent the intensity of red at each pixel, the blue channel has the values representing the intensity of blue at each pixel, and the green channel has the values representing the intensity of green at each pixel.

44. Images may also be captured or converted into other color spaces, such as the

YCbCr color space (luminance and chrominance) or the HSI (hue, saturation, and intensity). Each of these color spaces likewise has three channels. For example, the YCbCr color space has one luminance channel which is the luminance Y at each pixel, and two chrominance channels, which are the chrominance Cb and Cr at each pixel. The YCbCr color space representation is used to store JPEG images. An example[3] of these different representations of an image are in the figures below which shows a color image of the Grand Tetons at the left, and in the middle shows the RGB channels for that image, and to the right, shows the YCrCb channels for the image.



45. It is generally possible to convert from one color space to another using various mathematical formulas. For example, if one wanted the luminance of an RGB image, the luminance values at each pixel could be determined by converting the pixels from the RGB color space to the YCbCr color space using a linear formula. One would therefore have the luminance channel by looking at the obtained Y value at each pixel.

B. Photographic Lens Overview

46. A photograph is a two-dimensional rendering of a three-dimensional scene. All rays of light from the scene enter the lens, cross each other, and are rendered onto a two-dimensional plane known as the focal plane. These concepts are illustrated below for a simple thin lens:

[3] Example images from https://en.wikipedia.org/wiki/YCbCr.

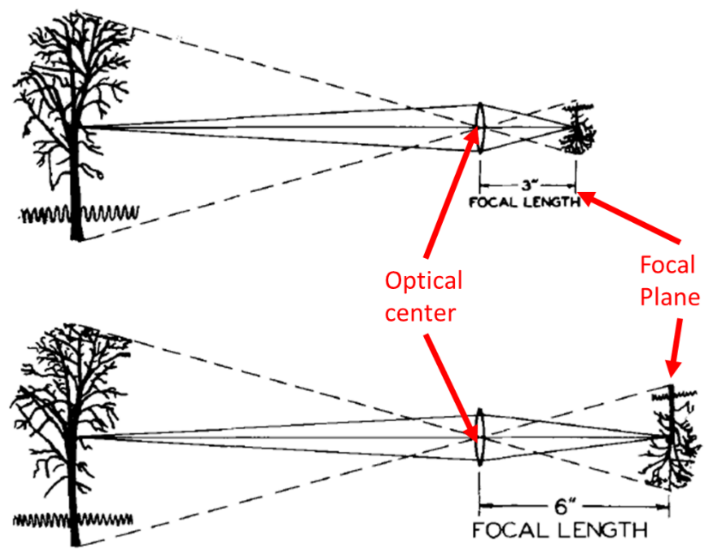


Figure 1.2. A lens of long focus produces a larger image than one of short focus.

Kingslake, Figure 1.2. In the figures, the dashed lines show the rays from a tree all going through the entrance of a camera, crossing, and forming an upside-down tree on the focal plane. The two-dimensional plane on which the image is focused is called the focal plane. In a camera, the focal plane may be located at the film or an electronic image sensor. The point at which the dashed lines above cross is also called the "optical center" or "center of perspective" for the camera. (Kingslake, at 2.)

47. The "focal length" measures how strongly an optical system converges light rays and the magnification it can achieve. If the focal length of the lens is long, the image is formed farther from the entrance and is larger (more magnified), as shown in the bottom figure above. If the focal length is shorter, the formed image is smaller (lower magnification), as shown in the top figure above.

48. The focal length is related to the field of view of the lens. The field of view is a measure of the angular extent of the scene captured by the lens As can be seen in the figure above, because the image projected on the focal plane is large, the actual image that results will only be as large as can be captured on the image sensor used to capture the image. In the figure below, I show this relationship by showing the same size image sensor being used to record images with two lenses – one with a longer focal length and one with a shorter focal length.

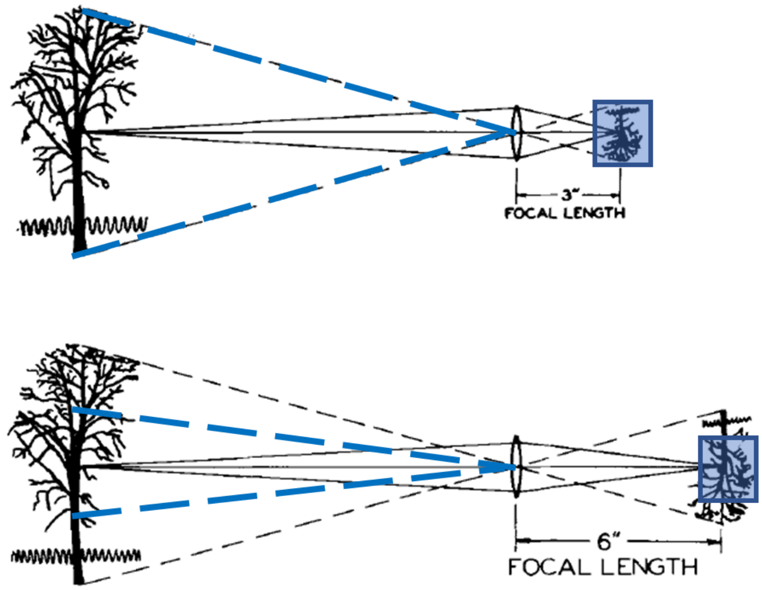


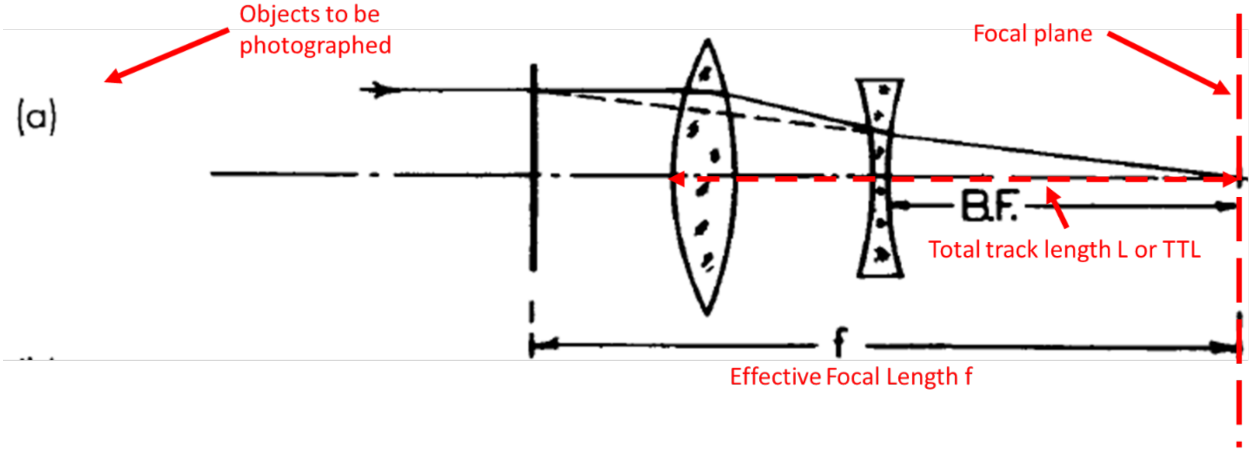
Figure 1.2. A lens of long focus produces a larger image than one of short focus.

Note that the same size image sensor in the device with the longer focal length captures a zoomed-in portion of the image. With the blue dashed lines, I show the field of view captured on each of the sensors. The shorter focal length lens captures a wider field of view, and the longer focal length lens captures a narrower field of view. Therefore given a particular image sensor or film size (for example 35mm), a longer focal length will indicate a narrower field of view, and a shorter focal length will indicate a wider field of view.

49. Because of the long term popularity of 35mm film, fields of view and focal lengths are still discussed in terms of their "35mm equivalent." That is, a camera with a particular lens and sensor has a 35mm equivalent focal length which is the focal length that would provide the same field of view in a 35mm camera. Given a particular sensor size, a lens is considered to have a "normal" (aka, "standard") field of view if it has approximately the same field of view as a 50mm focal length lens used with 35mm film, i.e., a field of view of approximately 50°. See, e.g., Ex. AE (London, Stone, and Upton, *Photography*, 11th Ed. (2013)), at 42 (explaining that a normal focal length lens of about 50mm with a 35mm film camera "approximates the impression human vision gives."). Similarly, a particular camera lens is said to be wide-angle or have a short focal length if it provides a total field of view larger than that of a 38mm focal length lens with 35mm film – i.e., a field of view of approximately 64-84 degrees. Ex. AE (*Photography*), at 46. And a camera lens

is considered narrow or long if it provides the field of view of a lens having greater than about 85 mm focal length with 35mm film , *i.e.*, about 23 degrees or less. *See, e.g., id.* at 44 (noting that 105mm is a popular long lens).

50. Most photographic lenses are made up of multiple lenses, which may be made of various glasses or plastics. The figure below shows an example of a lens made up of two lenses (the vertical dotted elements).



Kingslake, at 49, Figure 2.24(a). As is the convention, the objects to be photographed are on the left of the image. The plane on which the image is projected is on the right. Because the lens has multiple elements, the overall focal length of the lens – labelled "f" in the figure – is also sometimes referred to as its "effective focal length." The length of the lens (aka, total length or total track length) is the distance from the object-side surface of the first lens to the focal plane.

51. The lens in Figure 2.24(a) above is a special kind of long lens known as a telephoto lens, because its effective focal length is longer than the total length of the lens. *Id.*, at 49.

52. Some lay photographers and manufacturers for lay photographers use the term "telephoto" to refer to any lens with a longer focal length than normal, or a narrower field of view than normal. In fact, in one of my presentations for lay photographers, I have used the term telephoto in this way. [cite] However, this is not the definition of telephoto that is used by a POSITA for the term telephoto. The definition of a telephoto is one where the total length of the lens is less than the focal length, i.e., the ratio of total length to focal length is less than 1.0. As Kingslake notes, "It is common practice with some manufacturers to call any lens a 'telephoto' if

its focal length is longer than the normal value for that particular type of camera. This practice is, however, misleading and should be avoided."

VII. OVERVIEW OF THE '291 PATENT

53. The '291 Patent is titled "Dual Aperture Zoom Digital Camera" and was issued on June 18, 2019. The '291 Patent is directed to a "dual-aperture zoom digital camera operable in both still and video modes." '291 Patent, Abstract.[4]

54. In its background, the '291 Patent acknowledges that using digital zooming is an "alternative approach [to optical zooming] for approximating the zoom effect," and use of "multi-aperture imaging systems to approximate the effect of a zoom lens are known." '291 Patent, 1:39-50. For example, the '291 Patent acknowledges that US Patent Application Publication No. 2008/0030592 to Border et al. ("Border") describes a digital camera in which "two lenses have different focal lengths" with corresponding Wide and Tele sensors providing "Wide" and "Tele" images with different fields of view (FOVs) respectively. '291 Patent, 2:11-14. However, the '291 Patent alleges that Border "requires, in video mode, very large processing resources in addition to high frame rate requirements and high power consumption (since both cameras are fully operational)." *Id.*, 2:24-28. For further example, the '291 Patent acknowledges that US Patent Application Publication No. 2010/0277619 to Scarff ("Scarff") describes a camera with two lens/sensor combinations, where "the zoomed image is provided from the lens/sensor combination having a FOV that is next larger than the requested FOV" based on a zoom amount requested by a user, but alleges that Scarff "leads to parallax artifacts when moving to the Tele camera in video mode." '291 Patent, 2:29-44. The '291 Patent also alleges other deficiencies in the Border and Scarff prior art: that they have "degraded overall image quality" because "different focal length systems cause Tele and Wide matching FOVs to be exposed at different times using CMOS sensors;" that "[d]ifferent optical F numbers ('F#') cause image intensity differences; that they

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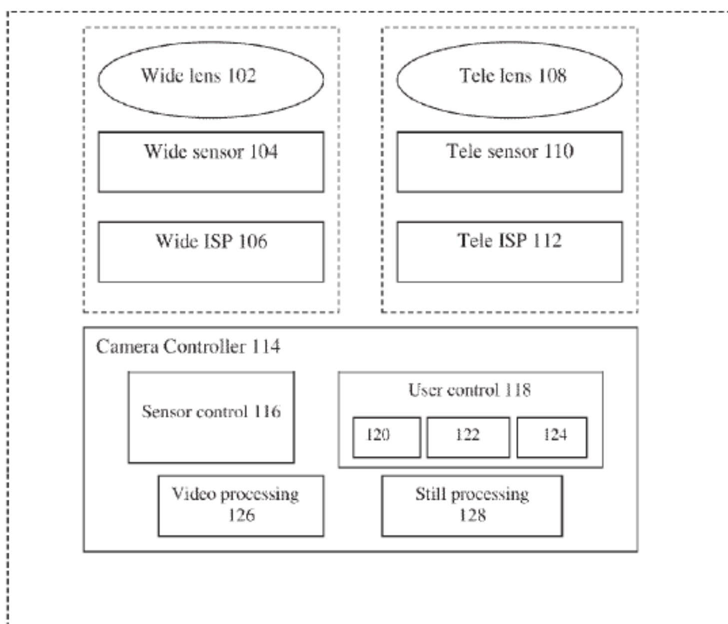
[4] I am informed and understand that the '291 Patent shares substantially the same written description as the '942 Patent that I previously addressed in IPR2020-00860. Accordingly, I present the following overview based on my overview of the '942 Patent presented in that IPR.

require double bandwidth support; that neither deals with registration errors; and that neither "refers to partial fusion, *i.e.* fusion of less than all the pixels of both Wide and Tele images in still mode." *Id.*, 2:45-56.

55. The '291 Patent alleges that none of the known art references "provide a thin (e.g., fitting in a cell-phone) dual-aperture zoom digital camera with fixed focal length lenses, the camera configured to operate in both still mode and video mode to provide still and video images, wherein the camera configuration uses partial or full fusion to provide a fused image in still mode and does not use any fusion to provide a continuous, smooth zoom in video mode." '291 Patent, 3:7-13.

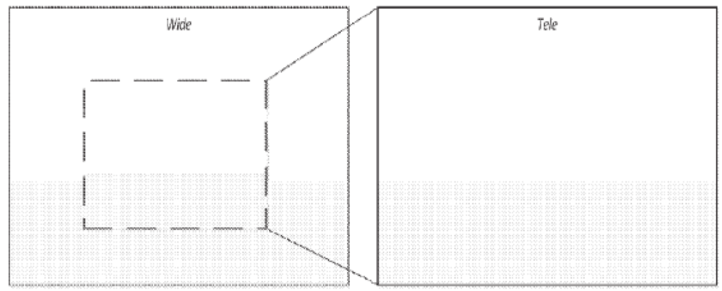
56. As an alleged solution to this problem, the '291 Patent describes a dual-aperture digital camera including "a Wide sub-camera and a Tele sub- camera." '291 Patent, 3:24-25.

57. FIG. 1A of the '291 Patent below illustrates a dual-aperture Zoom imaging system 100 including a first Wide imaging section and a second Tele imaging section, each having a respective lens, image sensor, and image signal processor (ISP).



'291 Patent, Figure 1.

58. FIG. 2 illustrates Wide and Tele sensors and their respective FOVs.



’291 Patent, Figure 2.

59. “In still mode, zoom is achieved ‘with fusion’ (full or partial), by fusing W and T images, with the resulting fused image including always information from both W and T images.” *Id.*, 3:36-38. “In video mode, optical zoom is achieved ‘without fusion,’ by switching between the W and T images to shorten computational time requirements, thus enabling high video rate.” ’291 Patent, 3:42-44.

VIII. CLAIM CONSTRUCTION OF THE ’291 PATENT

A. “Tele” and “Wide” terms

Term	Corephotonics’ Proposal	Apple’s Proposal
“Wide”	“Wide” refers to one of a pair of imaging sections with a wider field of view	No construction necessary. If the Court determines that construction is necessary, Apple would propose that “Wide” means “wide-angle,” or, alternatively, “wide-angle, characterized by an effective focal length (EFL) shorter than normal and field of view (FOV) wider than normal.”
“Tele”	“Tele” refers to one of a pair of imaging sections with a narrower field of view	telephoto, characterized by a TTL/EFL ratio less than 1. Alternatively, in the event the Court does not adopt that construction, Apple would propose that “Tele” means “telephoto, characterized by an effective focal length (EFL) longer than normal and field of view (FOV) narrower than normal.”

60. In my opinion, a POSITA would have understood the terms “Wide” and “Tele” in the ’291 Patent to refer to wide-angle and telephoto, respectively.

61. As an initial matter of terminology, the terms “Wide” and “Tele” themselves, in the context of the ‘291 Patent, would have suggested to a POSITA that they are shorthand for “**<u>wide</u>**-angle” and “**<u>tele</u>**photo” which were well-known concepts in the field.

62. The specification of the ’291 Patent confirms that this is the meaning of the terms

"Wide" and "Tele" that apply in the '291 Patent, based on the patent's discussion of a prior art patent application, U.S. Pat. Pub. No. 2008/0030592 to Border et al. ("Border"). The '291 Patent states as follows regarding Border and the "Wide" and "Tele" terms:

> In US 2008/0030592, two sensors are operated simultaneously to capture an image imaged through an associated lens. A sensor and its associated lens form a lens/sensor combination. The two lenses have different focal lengths. Thus, even though each lens/sensor combination is aligned to look in the same direction, each captures an image of the same subject but with two different fields of view (FOVs). One sensor is commonly called "Wide" and the other "Tele". Each sensor provides a separate image, referred to respectively as "Wide" (or "W") and "Tele" (or "T") images. A W-image reflects a wider FOV and has lower resolution than the T-image. . . .

'291 Patent, 2:3-16.

63. As described here, the '291 Patent applies the terminology of "Wide" and "Tele" to two sensors described in Border reference, and to the images produced by those two sensors. A review of Border confirms that Border describes two sensors as being associated with "wide-angle" and "telephoto" characteristics, respectively.

64. In its Background of the Invention section, Border describes that various camera systems were known in the prior art but did not provide the solution that Border described. For example, Border discusses U.S. Publication No. 2002/0075258 and states that this publication "does not address the case wherein **a wide-angle camera and a telephoto camera** are affixed together for simultaneous capture of the same scene." Border, at [0008].

65. Border describes a digital camera system that employs wide-angle and telephoto imaging simultaneously. Border describes providing a "**wide-angle**" imaging apparatus (including lens and sensor that Border calls a "**wide-angle image sensor**"), which capture a "**wide angle image**," together with a "**telephoto**" imaging apparatus (including lens and sensor that Border calls a "**telephoto second image sensor**") which capture a "**telephoto image**," as stated in Border's descriptions:

- "FIGS. 1A and 1B depict a block diagram of a digital camera using a fixed focal length **wide-angle lens** with a first image sensor and a zoom lens, or a longer second fixed focal length lens, with a second image sensor according to the present

invention." Border, at [0017], Figs. 1A, 1B.

- "FIG. 6 depicts a **wide angle image** as captured, a **telephoto image** as captured, and a composite image as created by the invention." *Id.*, at [0022], Fig. 6.
- "Turning now to FIG. 1A, a digital camera 10A is described which includes an image capture assembly, including a fixed focal length lens 2 that focuses an image of a scene (not shown) onto a first image sensor 12, and a zoom lens 3 which focuses an image of the scene onto a second image sensor 14. The image capture assembly 1 provides a first image output signal 12 e from the first image sensor 12 and a second image output signal 14 e from the second image sensor 14." *Id.*, at [0030].
- "The focal length of the fixed focal length lens 2 generates a **wide-angle** field of view and has a fixed focus set to a distance near the lens hyperfocal distance of 8 feet so that objects from 4 feet to infinity are in focus." *Id.*, at [0031].
- "As shown in FIG. 5, the image processor 50 of FIGS. 1A and 1B contains an image compositor 202 that receives both the **wide imag**e 204 from the fixed focal length lens 2 and the **telephoto image** 206 from the zoom lens 3." *Id.*, at [0036], Fig. 5.
- "In some embodiments of the present invention, the digital camera 10A is included as part of a camera phone. In such embodiments, the image processor 50 also interfaces to a cellular processor 90, which uses a cellular modem 92 to transmit digital images to a cellular network (not shown) using radio frequency transmissions via an antenna 94. In some embodiments of the present invention, the image capture assembly 1 can be an integrated assembly including the lenses 2 and 3, the image sensors 12 and 14, and zoom and focus motors 5." *Id.*, at [0055].
- "In a further preferred embodiment, as shown in FIG. 1B, digital camera 10B includes an adjustable focal lens system with two fixed focal length lenses 2 and 4, each providing an image to a corresponding image sensor 12 and 14. The digital camera 10B is capable of simultaneous image capture on both image sensors 12 and 14. The two fixed focus lenses are selected to provide a substantial zoom range, for example, 3:1 wherein the focal length of the second fixed focal length lens 4 is 3×

as long as the fixed focal length lens 2. As in digital camera 10A, a composite image is constructed from the two images captured on images sensors 12 and 14. Digital zoom is applied to the composite image between the image captured with the short fixed focal length lens 2 on first image sensor 12 and the image captured with the longer second fixed focal length lens 4 on second image sensor 14. The zoom control 42 c can provide zoom settings over the zoom range, for example, from 1 to 3. The remaining aspects of the digital camera 10B are similar to the digital camera 10A shown in FIG. 1A, and retain the same reference characters. Reference is therefore made to FIG. 1B for further description of these aspects of the digital cameras 10B." *Id.*, at [0058].

- "The first fixed focal length lens 612, preferably a fixed focal length **wide angle lens**, **forms an image on the first image sensor 614**, and the second fixed focal length lens 616, preferably a fixed focal length **telephoto lens** with a longer focal length, **forms an image on the second image sensor 618**." *Id.*, at [0065].
- "Moreover, the image processor 50 can provide digital zooming between the **wide angle** and the **telephoto** focal lengths; the user can initiate such zooming via a user interface displayed on the (LCD) display 608 and by keying appropriate buttons on the keypad 606. Furthermore, the **wide-angle image sensor 614** can have high resolution, e.g., higher than that of the **telephoto second image sensor 618**, in order to provide a higher quality source image for the digital zooming." *Id.*, at [0066].
- "In one embodiment, the **wide angle** first fixed focal length lens 612 is set to its hyperfocal distance, which means it is in focus from a few feet to infinity without need for any focus adjustment by the user. The **telephoto** second fixed focal length lens 616 is automatically focused by an auto focus subsystem 628 because the hyperfocal distance increases as the focal length increases requiring that the focus be adjusted in order to obtain proper focus for objects at typical (e.g. 4' to 12') distances. By using only one focusing subsystem 628 for the **telephoto** second fixed focal length lens 616, the cost and size can be reduced." *Id.*, at [0067].

66. Border's Figure 5 illustrates the "Wide Image" and "Telephoto Image" that are produced by the wide-angle lens and its corresponding image sensor, and the telephoto lens and its corresponding image sensor, respectively:

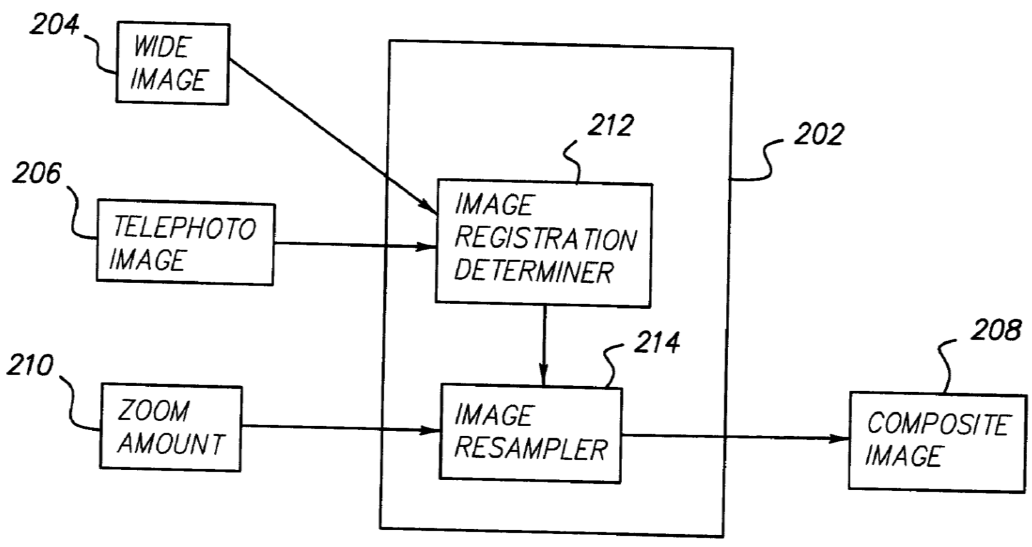


FIG. 5

67. Figure 6 of Border shows "a **wide angle image** as captured, a **telephoto image** as captured, and a composite image as created by the invention," Border, at [0022], as shown below with wide angle image 204 and telephoto image 206 (which are then combined into composite image 208):

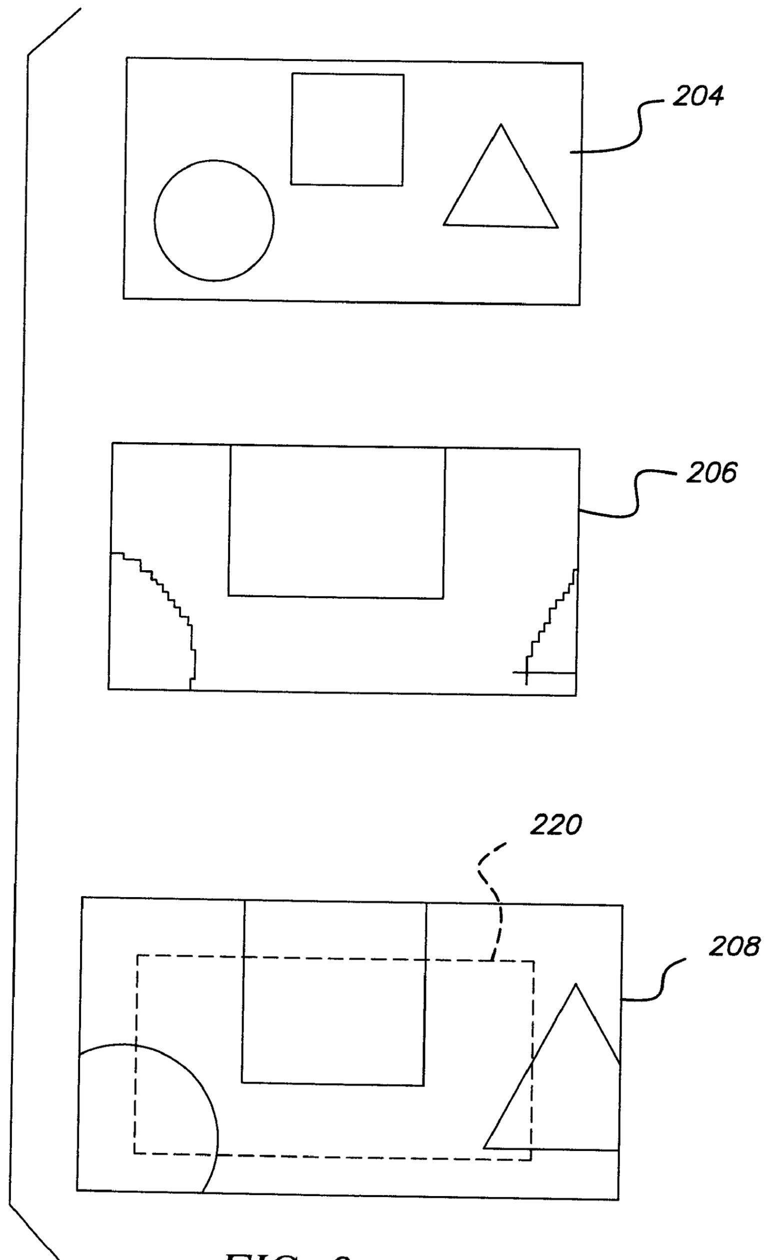


FIG. 6

68. In view of the descriptions in Border, a POSITA would have understood from the reference to Border in the '291 Patent specification that the terms "Wide" and "Tele" are shorthand terms to refer to wide-angle and telephoto, respectively.

69. I disagree with the assertion in the Hart declaration that the meaning where "Wide" and "Tele" refer to wide-angle and telephoto, respectively, "would result in uncertain claim scope."

Hart CC Decl. (Dkt. 148_11), ¶ 35. The Hart declaration states: "For example, were 'Wide' in the claims substituted with 'wide-angle,' claim 1 would require, among other things, a 'wide-angle sensor" and a 'wide-angle image signal processor,' both of which are meaningless phrases because neither a 'sensor' or 'image signal processor' can have a 'wide angle' in the sense of having a particular FOV or FOV within a particular range as Apple's second proposal requires." *Id.* The declaration similarly asserts that the meaning of "Tele" to refer to TTL/EFL<1 would result in "absurd claim scope" because it "would require a "telephoto [image sensor], characterized by a TTL/EFL ratio less than 1." Hart CC Decl. (Dkt. 148_11), ¶ 39.

70. I disagree with these assertions. In this regard, a POSITA would have understood that the '291 Patent borrows concepts and terminology from Border. Border explicitly describes its "**wide-angle image sensor**" and "**telephoto second image sensor**," much like the '291 Patent claims recite a "Wide sensor" and "Tele sensor." *E.g.*, Border, at [0066]. A POSITA would have understood that the "Wide" and "Tele" shorthand labels refer to the wide-angle and telephoto characteristics of the lens and the resulting image associated with other imaging components including the sensor, as described in Border and adopted by the '291 Patent, and also, in the '291 Patent claims, each associated "image signal processor ISP" as well.

71. I also note that the Hart declaration's assertions about an "absurd" result of applying a lens or image characteristic (wide-angle or telephoto) to an image sensor apply equally to Corephotonics' own constructions. Corephotonics proposes that "Wide" and "Tele" refer to "a wider field of view" or "a narrower field of view." Under the same reasoning as the Hart declaration states, a "sensor" or "image signal processor" itself does not have a particular field of view either. In fact, the Hart declaration states exactly that: "neither a 'sensor' or 'image signal processor' can have a 'wide angle' in the sense of having a particular FOV." Hart CC Decl. (Dkt. 148_11), ¶ 35.

72. Corephotonics argues that "Wide" and "Tele" were used in the '291 Patent to refer only to a "relative relationship between the imaging sections," not referring to the configuration of either section "in absolute terms." Hart CC Decl. (Dkt. 148_11), ¶ 32. I disagree. A POSITA would have understood that "Wide" and "Tele" are shorthand terms to refer to wide-angle and telephoto, which have well-understood meanings in the art that are not only a reference to a relative

relationship between imaging sections.

73. The Hart declaration cites U.S. Patent App. Pub. 2010/0277619 to Scarff ("Scarff"), which the '291 Patent cites at column 2, line 3. Hart CC Decl. (Dkt. 148_11), ¶ 32. I disagree with the assertion that in view of Scarff, a POSITA would have understood the "Wide" and "Tele" features to refer to "respective imaging "sections" as differing relative to one another rather than in absolute terms with respect to fields of view or total-track-length-to-focal-length (TTL/EFL) ratios." Hart CC Decl. (Dkt. 148_11), ¶ 32. As quoted in paragraph 32 of the Hart declaration, Scarff discusses a first lens with a "relatively-shorter focal length" and a first sensor that obtains an image with a "relatively-wider field of view (FOV)" and a second lens with a "relatively-longer focal length" and a second sensor that obtains an image with a "relatively-narrower FOV." Scarff, at [0012]. With the explicit use of the term "relatively", Scarff is characterizing the focal lengths and FOVs of the two lenses in relative terms, relative to each other.

74. However, the Hart declaration ignores the fact that the '291 Patent specification discusses and summarizes Scarff's disclosure at column 2, lines 29-42. '291 Patent, 2:29-42. Tellingly, in that discussion, the '291 Patent does **not** refer to Scarff's disclosure as disclosing "Wide" and "Tele" features. *Id.* This would have indicated to a POSITA that the terms "Wide" and "Tele" in the '291 Patent do **not** merely refer to the characteristic of having relatively narrower or wider field of view (FOV) as in Scarff, because if that were the meaning then the '291 Patent would have referred to Scarff's disclosure as providing "Wide" and "Tele" accordingly. Instead, a POSITA would have understood "Wide" and "Tele" in the '291 Patent in absolute terms as shorthand for wide-angle and telephoto, respectively.

75. The claim language of the '291 Patent also contradicts the meaning of "Wide" and "Tele" that Corephotonics and the Hart declaration assert, namely that "'Wide' and 'Tele' together refer to a pair of imaging sections that differ with respect to the FOVs captured by their lenses." Hart CC Decl. (Dkt. 148_11), ¶ 34. The claims of the '291 Patent separately and explicitly recite that the Wide and Tele lenses have "Tele imaging section that includes a fixed focal length Tele lens with a Tele FOV that is narrower than the Wide FOV" (claim 1) or similarly "Tele imaging section having a Tele lens with a Tele FOV that is narrower than the Wide FOV" (claim 12). In

other words, the claims already state that the "Tele FOV . . . is narrower than the Wide FOV." This would indicate to a POSITA that the terms "Tele" and "Wide" do not simply refer only to a relatively narrower or wider FOV of the lenses of the imaging sections, because the claims already separately state the relatively narrower and wider FOVs of the lenses of the imaging sections. Corephotonics' proposed construction would make that separately-recited claim language redundant and superfluous.

76. I have also been asked to opine upon the meaning of "telephoto" that a POSITA would have understood in the context of the '291 Patent. In my opinion, a POSITA would have understood "telephoto" according to its standard technical meaning in the relevant field, referring to the lens design characteristic where the total track length (TTL) is smaller than effective focal length (EFL). This meaning is described in reference texts, for example.

77. The following excerpts from the Kingslake (1992) text provide a discussion on this point. This Kingslake text was discussed in IPR2020-00860 that I was involved with, as discussed further below.

> Some *narrow-angle* lenses are loosely called "telephoto" lenses because they have a longer focal length than the normal lens and thus give a picture to a larger scale. However, **the name "telephoto" should be restricted to a lens of a particularly compact type of construction (see page 148), in which the distance from the front of the lens to the film plane is less than the focal length of the lens**.

Kingslake, *Optics In Photography* (1992) (Ex. C), at 8-9.

> The Telephoto Lens
>
> This is a lens of a special type of construction, comprising a positive front component widely separated from a negative rear component. As is indicated in Fig. 2.24(a), this form of construction has the property that the second principal plane lies outside the positive end of the system. **The total length from the front lens vertex to the image plane is therefore less than the focal length**, a real advantage in lenses of very long focal length. However, it is more difficult to achieve good aberration correction in a telephoto lens than in a lens of a more normal type; consequently, a telephoto lens is used primarily when compactness demands it.
>
> It is common practice with some manufacturers to call any lens a "telephoto" if its focal length is longer than the normal value for that particular type of camera. This practice is, however, misleading and should be avoided. Telephoto lenses are discussed on page 148.

Id. at 49.

> It was mentioned on page 49 that the telephoto lens consists of a positive front component widely separated from a negative rear component, the consequence of this arrangement being that **the posterior principal plane is out in front and the total length from front vertex to film plane is shorter than the focal length (Fig. 7.11)**. The *telephoto effect* is the ratio of the total length to the focal length, and in most telephoto lenses its value is about 0.8. Because of the difficulty of designing good lenses of this type, telephoto lenses are used only when the total length must be kept short, as, for instance, in SLR camera lenses of focal length greater than about 150 mm. Occasionally a 135 mm telephoto lens is encountered, but there is little need to shorten the lens in this focal length, particularly as normal lenses have much smaller aberration residuals.

Id. at 148. Figure 7.11 of Kingslake is reproduced below.

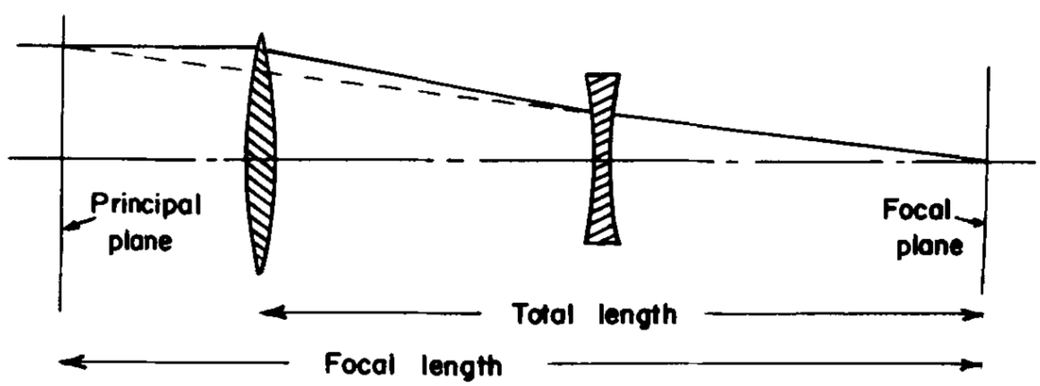


Figure 7.11. Principle of the telephoto lens.

78. Another reference text by Warren J. Smith (1992) explains similarly as follows. This Smith text was also discussed in IPR2020-00860, as discussed further below.

> 10.1 The Basic Telephoto
>
> The arrangement shown in Fig. 10.1, with a positive component followed by a negative component, can produce a compact system with an effective focal length F which is longer than the overall length L of the lens. The ratio of L/F is called the telephoto ratio, and **a lens for which this ratio is less than unity is classified as a telephoto lens**. Note that many camera lenses which are sold as camera lenses are simply long-focal-length lenses and are not true telephotos.

Smith, *Modern Lens Design: A Resource Manual* (1992) (Ex. E), at 169. Figure 10.1 from Smith

(1992) is reproduced below.

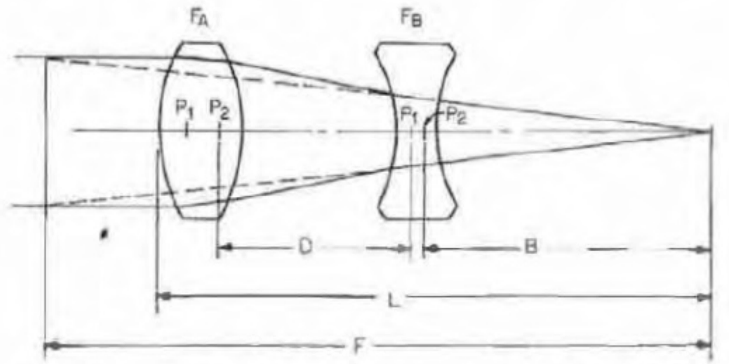


Figure 10.1 The basic power arrangement for a telephoto lens yields a compact lens with an overall length which is less than its effective focal length.

79. Another reference text (authored by a different Smith, Gregory Hallock Smith) similarly explains:

> Contrary to much popular usage, a telephoto lens is not merely a lens having a relatively long focal length and narrow field of view. A **true telephoto lens** has negative power in its rear section to create a more compact and convenient system whose **physical length is shorter than its EFL**. This unsymmetrical configuration is shown in Fig. 8.5.

Smith, *Camera Lenses* (2006) (Ex. H), at 59. Figure 8.5 from Smith (2006) is reproduced below.

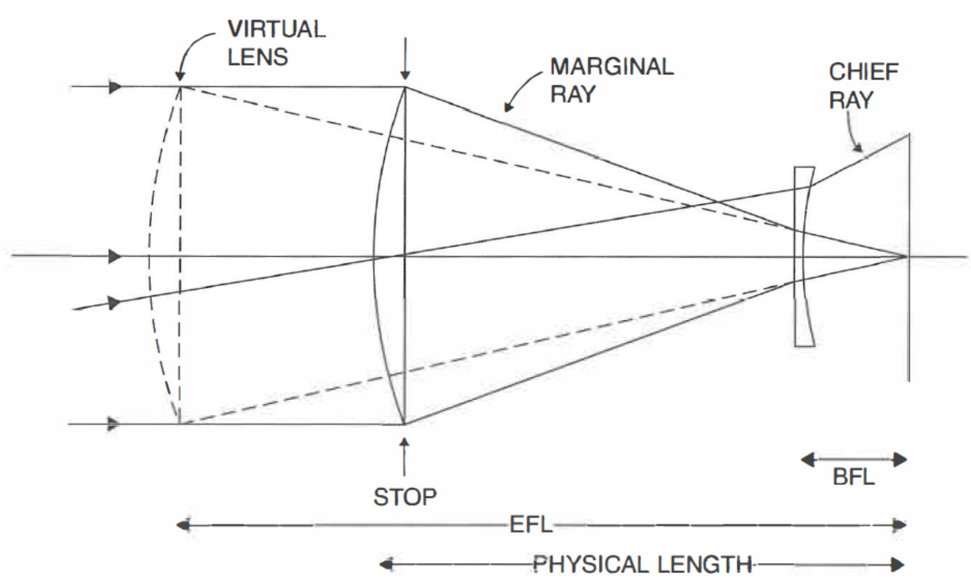


Figure 8.5 Telephoto lens. From *Practical Computer-Aided Lens Design* published by Willmann-Bell, Inc. (www.willbell.com) Used with permission.

80. Another reference text by Malacara similarly explains:

> The telephoto lens has two basic elements: a positive lens in the front and a negative lens in the back. **The effective focal length of the system is larger than the total length**, from the front lens to the focal plane, of the system.

Malacara, *Handbook of Optical Design* (2d Ed., 2004) (Ex. D), § 12.2.2.

81. These reference texts are consistent with, and support, the understanding that a POSITA would have had of the meaning of the term "telephoto" in the relevant context of the '291 Patent. "Telephoto" refers to the configuration where the total length (TTL) is less than the focal length (EFL), so that the ratio of TTL/EFL is less than one.

82. This understanding is also consistent with the specification of the '291 Patent that discusses the "Tele" telephoto lens in terms of its TTL/EFL ratio. The patent states: "In one embodiment, the Tele lens TTL/EFL ratio is smaller than 0.9. In other embodiments, the Tele lens TTL/EFL ratio may be smaller than 1." '291 Patent, 12:13-28. The specification does not disclose any "Tele" lens with a TTL/EFL ratio of 1.0 or greater. Based on the '291 Patent's disclosure of the TTL/EFL ratio being smaller than 1, a POSITA would have further understood that the term "Tele" was being used in the patent to mean "telephoto" with the meaning of TTL/EFL<1. In context, where the specification states "[i]n one embodiment, the Tele lens TTL/EFL ratio is smaller than 0.9" and then "[i]n other embodiments, the Tele lens TTL/EFL ratio may be smaller than 1," a POSITA would have understood this to mean that one particular embodiment would have a TTL/EFL ratio smaller than 0.9, but other embodiments could have other TTL/EFL ratios that are smaller than 1.0, all consistent with the meaning of "telephoto" defined as TTL/EFL<1.

83. I note that, as noted in paragraph 41 of the Hart declaration, dependent claim 6 of the '291 Patent recites: "The camera of claim 1, wherein the Tele lens includes a ratio of total length (TTL)/effective focal length (EFL) smaller than 1." In my opinion, this claim would not have changed the meaning of "Tele" that a POSITA would have understood in the context of the '291 Patent. The specification does not describe any Tele lens with a TTL/EFL ratio of 1.0 or greater. I have been informed and understand that "claim differentiation" is a legal doctrine under which it is "presumed" that different claims in a patent have different scope, but I am also informed and

understand that this is only a presumption, not a strict rule. I am not an expert on the law, but in my opinion from a technical perspective, "Tele" would have been understood by a POSITA to be shorthand for "telephoto," and the applicable meaning of "telephoto" in this context would have been the TTL/EFL<1. These understandings from a technical perspective would not be changed by the fact that claim 6 also recites that the Tele lens has a TTL/EFL smaller than 1.

84. As noted in the reference texts quoted above, there was also a layperson usage of the term "telephoto" that could refer to a lens with a long focal length. However, from a technical perspective, merely having a long focal length is not, by itself, sufficient to define a true telephoto lens, as these texts explain. In my opinion, the term "Tele" in the '291 Patent would have been understood by a POSITA to refer to "telephoto" with the standard technical meaning of TTL/EFL<1.

85. To the extent the term "telephoto" were to be interpreted according to a layperson meaning that did not require the TTL/EFL<1 telephoto ratio, then alternative meanings of telephoto and wide-angle, respectively, would be that telephoto is characterized by an effective focal length (EFL) longer than normal and field of view (FOV) narrower than normal, and wide-angle is characterized by an effective focal length (EFL) shorter than normal and field of view (FOV) wider than normal. In other words, a POSITA would understand that there is a "normal" focal length and field of view for a given camera, and in a layperson usage (as well as in a technical usage), "telephoto" and "wide" are on opposite sides of the "normal" value for both focal length and field of view.

86. This layperson meaning is explained in the reference texts. As Kingslake notes, a layperson meaning of "telephoto" would sometimes refer to a lens with a focal length that has a focal length longer than "normal" and a field of view that is narrower than "normal." Kingslake, at 8-9 ("Some *narrow-angle* lenses are loosely called 'telephoto' lenses because they have a **longer focal length than the normal lens** and thus give a picture to a larger scale."), 49 ("It is common practice with some manufacturers to call any lens a 'telephoto' if its focal length is longer than the **normal** value for that particular type of camera. This practice is, however, misleading and should be avoided."). Similarly, a "wide-angle" lens can be characterized by having a focal length that is

shorter than normal, and a field of view that is wider than normal, for a given camera. This is explained, for example, in the Smith (2006) reference:

> So far we have looked at standard or normal lenses for large-format cameras. A **normal** lens has a focal length roughly equal to the length of the film format diagonal. For 4 x 5 film, this is 162.6 mm, or 150 mm when rounded. **Pictures made with normal lenses have a perspective that is normal-looking to most people**. However, for many types of subject matter, a wider field of view is required, and for this you need **a wide-angle lens having a shorter focal length**. Wide-angle lenses are very popular for use on large-format view cameras and field cameras. They are almost as popular as normal lenses.

Smith, *Camera Lenses* (2006) (Ex. H), at 163.

87. I have also given a slideshow presentation that discusses the concept of "normal" including "normal" focal length and "normal" field of view, which Corephotonics previously cited during IPR proceedings. I am informed and understand that an excerpt of the slideshow is being submitted here as Exhibit I, including the first 19 pages that address concepts that are discussed here. I am informed and understand that the full 195-page slideshow is publicly available online as Exhibit 2002 in IPR2020-00905.

88. As discussed in pages 8-15 and summarized on page 19 of my slideshow, it is commonly understood that there is a "normal" (or "standard") set of lens parameters for a given camera. Traditionally, and as discussed in my presentation, a normal focal length is approximately 50 or 55 mm and a normal field of five is approximately 46 degrees. Increasing the focal length narrows the field of view, and vice versa. These points are shown for example on pages 8 and 10 of my presentation (including a caption of "Normal 50 mm") and page 13 (showing "Normal: neutral") images of 50mm or 55m focal lengths.

89. Importantly, "wide angle" and "telephoto" are considered to have **objective** values or ranges anchored around the concept of the "normal" for a given lens, as opposed to being merely relative to one another as Corephotonics appears to argue. As noted in my presentation, when considering wide angle and telephoto from this context, "wide angle" corresponds with approximately "<35mm" (a focal length of less than 35 mm) and "telephoto" corresponds with approximately "> 85mm" (a focal length of more than 85 mm), which are on opposite sides of the

"normal" focal length of approximately 50-55 mm. A POSITA would not have understood "wide angle" and "telephoto" (or "Wide" and "Tele" in the '291 Patent claims) to merely refer to any arbitrary two lenses with relatively longer or shorter focal lengths, or relatively wider or narrower fields of view, as Corephotonics and the Hart declaration assert. For example, if a first lens has a relatively shorter focal length of 25 mm and a second lens has a relatively longer focal length of 30 mm, that does not mean the first lens is "wide angle" but the second lens is "telephoto."

90. The Hart declaration states that "the concepts of 'normal' EFL and 'normal' FOV do not exist in the art, and would not be apparent to a POSITA." Hart CC Decl. (Dkt. 148_11), ¶ 36. I disagree. The concepts of a "normal" lens with a corresponding "normal" focal length and "normal" FOV were well-known in the art before the '291 Patent and would have been well-known to a POSITA, as reflected in the texts discussed above.

91. I note that in IPR2020-00860 regarding related U.S. Patent No. 10,326,942, which is a continuation patent from the '291 Patent that shares the same written description, I provided opinions regarding the disclosure of telephoto lenses in certain prior art references. In connection with that proceeding, Corephotonics cited a slideshow presentation I had given that discussed telephoto lenses. As I explained at my deposition and my reply declaration in that proceeding, that presentation was "intended for people taking photographs, not designing lenses and cameras." In other words, the presentation was not presented for a POSITA in the relevant field. In my opinion, when considering the meaning of "Tele" as "telephoto" in the context of the '291 patent, a POSITA would have understood the term with its correct technical meaning to refer to a true telephoto lens with a TTL/EFL ratio less than 1.0, not with its layperson meaning. I note that in IPR2020-00860, the PTAB addressed this issue in its Final Written Decision and determined that "telephoto" would have been understood with the technical meaning of TTL/EFL<1 in the context of the '942 Patent with the same specification. For reference, excerpted below is a portion of the PTAB's decision which further discusses the issues that I have addressed.

> Patent Owner also points to a presentation given by Dr. Durand to graduate students at MIT. PO Resp. 62 (citing Ex. 2002; Ex. 2014, 55:23–56:24). In that presentation, Patent Owner contends Dr. Durand "explained what a 'telephoto' lens was in terms of the focal lengths of telephoto lenses for 35 mm cameras," which Patent

Owner uses to support its contention that "the term 'telephoto' (and the even less formal 'tele') are commonly used to refer to a range of focal lengths, rather than a ratio of TTL/EFL." *Id.* (citing Ex. 2002, 14–15, 19).

Patent Owner supports its contentions with citations to Smith and Kingslake. Smith discloses that "many camera lenses which are sold as telephoto lenses are simply long-focal-length lenses and are not true telephotos." Ex. 1023, 169. Kingslake discloses that "[s]ome narrow angle lenses are loosely called 'telephoto' lenses because they have a longer focal length than the normal lens and thus give a picture to a larger scale." Ex. 2016, 8–9.

Patent Owner contends that Parulski, being concerned with size, addresses shortening an EFL, but does not teach or suggest reducing the ratio of EFL/TTL to less than one. Patent Owner contends that tele lens or telephoto lens would have been understood to have a narrow FOV, but not to have an EFL/TTL of less than one. PO Resp. 62 (Ex. 2002, 14–15, 19). Patent Owner makes similar arguments with respect to Golan. *See id.* at 63–64.

Petitioner does not respond to Patent Owner's arguments. *See generally* Pet. Reply.

The issue we must decide is whether a POSITA would have understood the EFL/TTL to be less than one in either Golan or Parulski's tele lens. We have what amounts to possibly competing definitions of tele lens or telephoto lens. On the one hand, Smith and Kingslake have a narrower definition for a telephoto lens that requires a narrow FOV and TTL/EFL is less than one. Ex. 1023, 169; Ex. 2016, 8–9. On the other hand, Smith, Kingslake, and Dr. Saber's testimony about Dr. Durand's presentation to his students indicate that a telephoto lens is sometimes loosely used to refer to lenses with only a narrow FOV or long focal lengths. *See id.*; Ex. 2002; Ex. 2014, 55:23–56:24.

As to Patent Owner's argument regarding the use of the term telephoto in the specification, we do not view the specification's use of the term as dispositive to the issue at hand because the dispute is not a matter of claim construction (i.e., the scope of claim 8 is undisputed), but rather, how a POSITA would have understood that Golan and Parulski used the term. Nevertheless, even regarding how the '942 specification uses the term, Patent Owner does not explain sufficiently what other embodiments purportedly exist in the '942 specification where a tele lens does not have an EFL/TTL less than one. Further, we do not agree that the specification defines a tele lens as being broader than an EFL/TTL less than one. Patent Owner has provided no example of such a definition in the specification.

Patent Owner asserts that "Durand confirmed that this definition of telephoto lenses in terms of their focal length or their FOV (independent of TTL) is how the '*average user*' of lenses 'would mostly think of' telephoto lenses." PO Resp. 62 (citing Ex. 2014, 62:2–15; Ex. 2015 ¶ 155) (emphasis added). Patent Owner also

> asserts that "when Parulski introduces the concept of 'telephoto lens' it characterizes that lens in terms of FOV, as a *camera user* would, and not in terms of TTL/EFL." *Id.* at 63 (citing Ex. 2015 ¶¶ 156–157).
>
> In the present proceeding, a POSITA is not an "average user" or merely a "camera user;" he or she would have multiple years of experience with at least imaging systems. *Supra* § III.B. Thus, we find that the POSITA would have used the definitions that Smith and Kingslake indicate are accurate (or more precise), rather than the definitions that Smith and Kingslake indicate are loose or inaccurate (or less precise). We also determine that the prior art, which includes Golan and Parulski, to be reflective of the level of ordinary skill in the art during the relevant timeframe. *Id.* Accordingly, we determine that a POSITA would understand Golan and Parulski to teach a telephoto lens using what Smith and Kingslake teach describe as the more accurate definition for that term.
>
> Whether the '942 patent uses the broader definition for that term would not alter Golan's and Parulski's teachings. So a POSITA would understand what Golan and Parluski teach in terms of what the ordinary meaning of the term would be at the time of the invention

IPR2020-00860, Final Written Decision, at 67-70.

B. "Fusion" terms

Term	Corephotonics' Proposal	Apple's Proposal
"fused"	None but see proposal for fused output image as "output image including a combination of image information from two images"	formed into a composite that includes pixels from the Wide and Tele images.
"fusion"	None but see proposal for "without fusion … output images" as "output images not created by combining image information from two images"	forming a composite that includes pixels from the Wide and Tele images.

92. The meaning of the terms "fused" or "fusion" in the '291 Patent are the same as a POSITA would understand the terms to mean.[5] There is no well established definition in the field of photographic imaging for "fusion." I note that Corephotonics also fails to provide a citation to an authoritative definition. However, the meaning of the term is well circumscribed, i.e., a POSITA would understand what is fusion and what is not fusion. A POSITA would understand the terms fused and fusion to mean forming a composite that includes pixels from multiple images. A person

[5] I will refer to the definition of "fusion" below, but my arguments apply equally to "fused," which is merely an adjective describing something that results as an output of fusion

of ordinary skill in the art reviewing the ’291 Patent in context would have understood the term fusion in the context of the ‘291 patent to understand that fusion occurs here within the context of images from Wide and Tele cameras, and would thus understand fusion to mean forming a composite that includes pixels from the Wide and Tele images.

i. “Fusion” in the ‘’291 Patent Means forming a composite of Pixels From the Wide and Tele Images.

93. The ’291 Patent uses fusion specifically to refer to combinations of pixels from the Wide and Tele images.

94. ***First***, the ‘291 describes fusion in describing the Border prior art reference. As the ‘291 Patent explains, in Border:

> two sensors are operated simultaneously to capture an image imaged through an associated lens. A sensor and its associated lens form a lens/sensor combination. The two lenses have different focal lengths. Thus, even though each lens/sensor combination is aligned to look in the same direction, each captures an image of the same Subject but with two different fields of view (FOVs). One sensor is commonly called “Wide” and the other “Tele'**. Each sensor provides a separate image, referred to respectively as “Wide (or “W) and “Tele” (or “T”) images.** AW-image reflects a wider FOV and has lower resolution than the T-image. **The images are then stitched (fused) together to form a composite (“fused’) image.** In the composite image, the central portion is formed by the relatively higher-resolution image taken by the lens/sensor combination with the longer focal length, and the peripheral portion is formed by a peripheral portion of the relatively lower-resolution image taken by the lens/sensor combination with the shorter focal length. The user selects a desired amount of Zoom and the composite image is used to interpolate values from the chosen amount of Zoom to provide a respective Zoom image.

’291 Patent, 2:4-24. As this passage from the ‘291 Patent recognizes, Border uses the term “stitching” to describe the combining of the Wide and Tele images into a “composite” image. This passage in the ’291 Patent merely redefines this process as “fusion.” A POSITA would understand that fusion as used in the ’291 patent includes stitching two images to create a composite image, as taught in Border as incorporated into the ‘291 Patent.

95. “Stitching” and a “composite” image are described further in Border. Figure 5 in Border, reproduced below, “is a block diagram of the stitching process to create the composite image.”

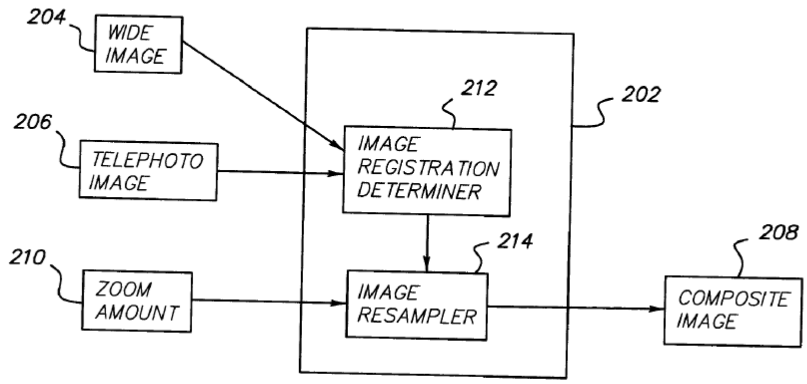


FIG. 5

Ex. B (Border), Figure 5, Para [0021]. This figure shows that a Wide image 204 and a Telephoto image 206 are input to a registration determiner 212 that "determines the registration between the wide image 204 and the telephoto image 206." *Id.*, ¶ 38. Then, "[t]he image resampler 214 uses the registration information and the zoom amount 210 to produce the composite image 208." *Id.*, Para 43.

96. Figure 6 in Border, reproduced below, provides a graphical example of such stitching to provide a composite image, showing "a wide angle image as captured, a telephoto image as captured, and a composite image as created by the invention… ." *Id.*, Para [0022].

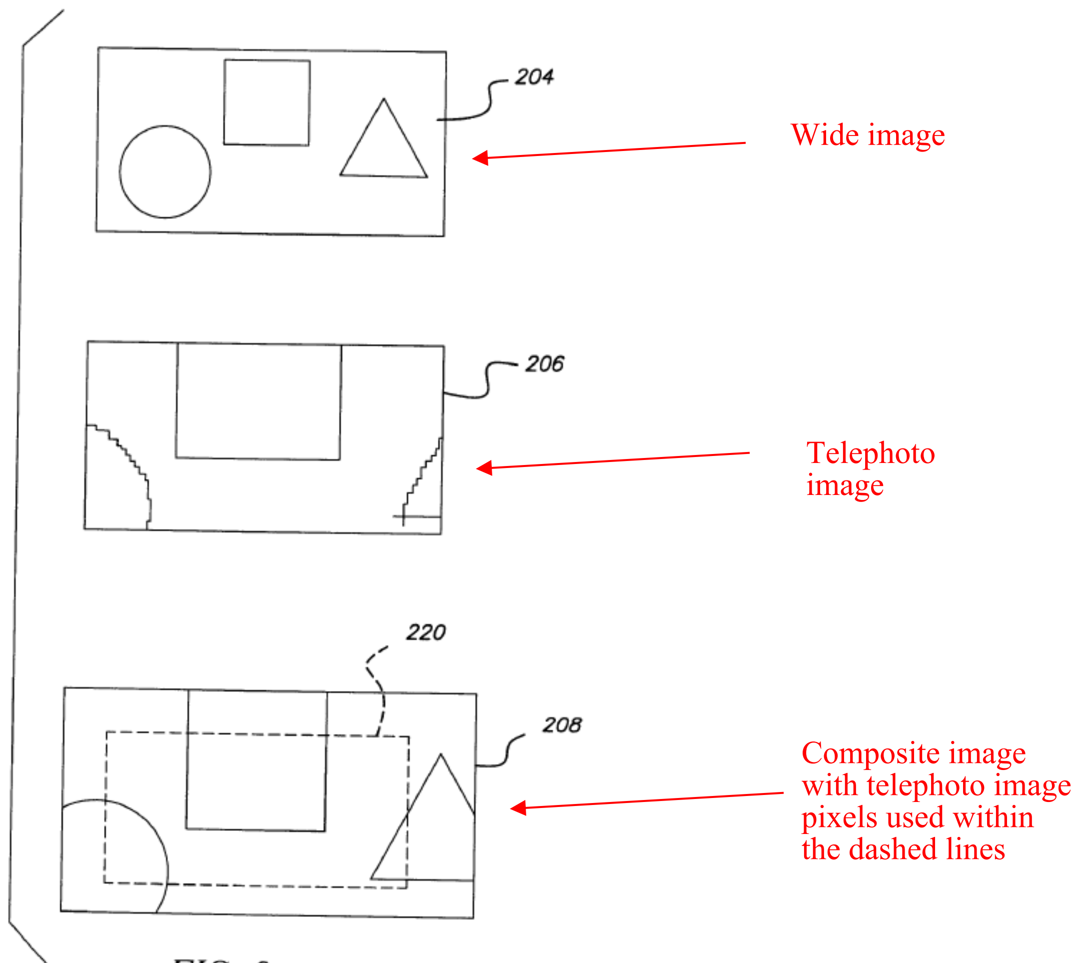


FIG. 6

Id., Figure 6. As can be seen in the figure above and explained in Border:

> **The wide image 204 covers a wide portion of the scene and the telephoto image 206 covers a smaller portion of the scene, but with greater resolution. The produced composite image 208 uses pixel data from the telephoto image 206 for those portions (i.e., the region within the dashed line 220) that are in the view of the telephoto image 206 and uses pixel data from the wide image 204 otherwise** (i.e., the region outside the dashed line 220). Thus, the composite image 208 has higher resolution in the interior and lower resolution on the edges. Since the Subject of a photograph, especially in consumer photography, is likely to be near the center of the scene, the subject of the composite image 208 is likely to have the highest resolution.

Id., ¶ [0047]. A POSITA would understand that Border thus shows that stitching uses the pixels from the wide image 204 in the outer portion of the composite image 208 and using all of the pixels from the telephoto image 206 in the center portion of the composite image 208. The '291 Patent reiterates this process, merely replacing the words "stitch" and "composite" with the term "fused."

'291 Patent, 2:11-16 ("The images are then **stitched (fused)** together to form **a composite ("fused") image**"). Thus, a POSITA would understand the verb "fused" to refer to combining the pixels from the Wide and Tele images to form a composite image, and the adjective "fused" to refer to a composite formed by using the pixels from the Wide and Tele images.

97. ***Second***, in distinguishing the '291 Patent's invention from the prior art based on their lack of partial fusion, the '291 Patent explains that fusion requires combining pixels from the two images. The '291 Patent distinguishes Border and another prior art reference US 2010/0277619 ("Scarff") on the basis (among others) that they do not "refer to partial **fusion**, ***i.e.*, fusion of less than all the pixels of both Wide and Tele images** in still mode." '291 Patent, 2:53-54.[6] A POSITA would understand the '291 Patent to be stating that fusion requires combining pixels of the Wide and Tele images, but could be partial, where partial fusion means combining less than all of the pixels of the Wide and Tele images. A POSITA would understand this to mean that fusion requires combining pixels as in Border, but also could be partial fusion, such that only some of the pixels are combined. This confirms that in both full and partial fusion, it is pixels from both images that get combined into a composite image, rather than the mere use of secondary or aggregate information to modify one of the two images.

98. The '291 Patent further describes partial fusion in the "Summary of the Invention" section, where the patent describes features that are present in all "Embodiments disclosed herein." *Id.*, 3:22. The patent states:

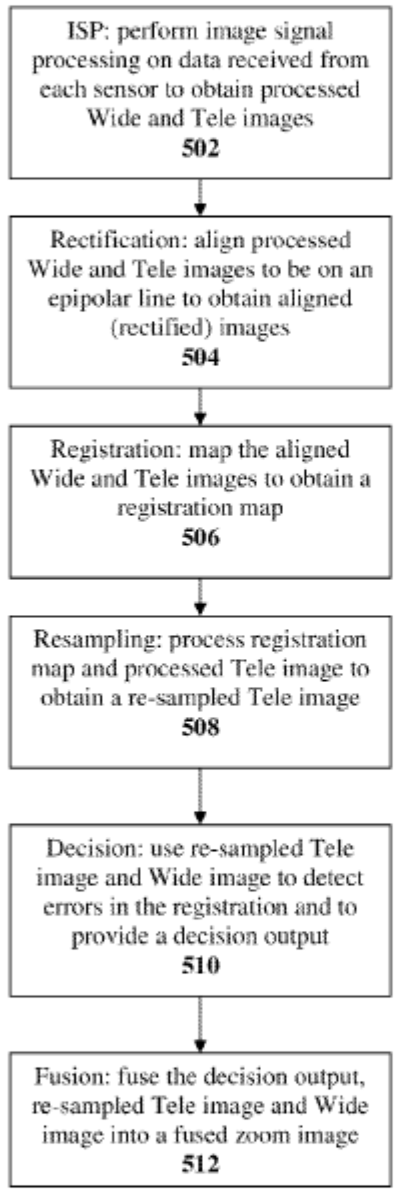
> The digital camera can be operated in both still and video modes. **In still mode, zoom is achieved "with fusion' (full or partial)**, by fusing W and T images, with the resulting fused image including always information from both W and T images. **Partial fusion may be achieved by not using fusion in image areas where the Tele image is not focused.**

Id., 3:34-40. Thus, the '291 Patent explains that partial fusion can be achieved by not using fusion in image areas where the Tele image is not focused, i.e., not using the pixels from the Tele image that are not focused when combining with the Wide pixels. Thus, the '291 Patent's distinction as

[6] While the '291 Patent refers to US 2008/000592 ('291 Patent, 2:53-54), it is clear from the context of the paragraph that this is a typographical error and should have referred to US 2008/0030592 (Border). Indeed, US20080000592 is a patent publication entitled, "Cord-winding device for a window blind," which is clearly unrelated to the subject matter of the '291 Patent.

to its use of partial fusion would again support a POSITA's view that fusion requires combining the pixels from Wide and Tele images.

99. ***Third***, the only embodiment provided in the '291 Patent for how to perform fusion requires combining the Wide and Tele image pixels. Specifically, Figure 5 of the '291 Patent is reproduced below:

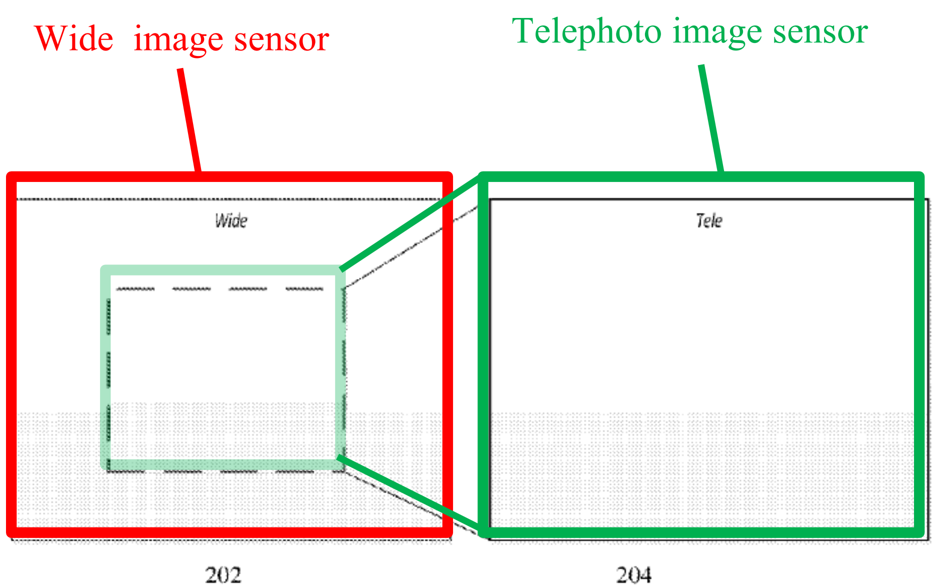


'291 Patent, Figure 5. The '291 Patent describes this as follows:

> FIG.5 shows an embodiment of a method disclosed herein for acquiring a zoom image in still mode. In ISP step 502, the data of each sensor is transferred to the respective ISP component, which performs on the data various processes such as denoising, demosaicing, sharpening, scaling,

> etc., as known in the art. After the processing in step 502, all following actions are performed in capture processing core 128: in rectification step 504, both Wide and Tele images are aligned to be on the epipolar line; in registration step 506, mapping between the Wide and the Tele aligned images is performed to produce a registration map; in resampling step 508, the Tele image is resampled according to the registration map, resulting in a re-sampled Tele image: in decision step 510, the re-sampled Tele image and the Wide image are processed to detect errors in the registration and to provide a decision output. In more detail, in step 510, the re-sampled Tele image data is compared with the Wide image data and **if the comparison detects significant dissimilarities, an error is indicated. In this case, the Wide pixel values are chosen to be used in the output image**. Then, in fusion step 512, the decision output, **resampled Tele image and the Wide image are fused into a single Zoom image.**

Id., 9:15-36. I will use Figure 2 from the '291 patent, below, to explain this process.



Id., Figure 2 (with color annotations added). Figure 2 from the '291 Patent shows the Wide image sensor 202 (in red above) and the Tele image sensor 204 (in green above), and the respective fields of view. *Id.*, 7:26-27. As shown by the figure, the field of view of the Tele only encompasses the area within the dashed lines of the Wide. Therefore, fusing them requires several steps. First, Step 504 rectifies the two images (*i.e.*, aligns them). *Id.*, 9:21-23. Then, Step 506 registers the images, *i.e.*, finds where the pixels of one appear in the other, to create a registration map (a matrix including for each pixel where it can be found in the other image). *Id.* 9:23-25. Step 508 then resamples the Tele image to make the Tele image have only the number of pixels within the dashed area of the Wide image that it will replace. *Id.* 9:25-27. In Step 510, the process compares the resampled

pixels of the Tele with the original pixels within the dashed area of the Wide image. *Id.* 9:27-32. If there are "significant dissimilarities," then the process assumes there is a mistake and just uses Wide image pixels. *Id.* Otherwise, "the resampled Tele image and the Wide image are fused into a single zoom image," which would be understood to mean that the resampled Tele image pixels are used within the dashed area of the Wide image.

100. ***Fourth***, the description of "Wide fusion" and "Tele fusion" in the '291 Patent further support a POSITA's understanding that fusion is combining pixels from the Wide and Tele images. The '291 Patent explains that fused images can either be Wide fusion or Tele fusion:

> In fused images, it is possible to register Tele image pixels to a matching pixel set within the Wide image pixels, in which case the output image will retain the Wide POV ("Wide fusion"). Alternatively, it is possible to register Wide image pixels to a matching pixel set within the Tele image pixels, in which case the output image will retain the Tele POV ("Tele fusion').

Id., 5:5-11. Thus, the '291 Patent states that the registration (as shown in Step 506 of Figure 5 above), can be performed by registering Tele image pixels to Wide image pixels ("Wide fusion"), or by matching Wide image pixels to Tele image pixels ("Tele fusion"). *Id.* Again, the '291 Patent describes fusion in terms of matching ***pixels*** (which would later be combined).

101. Corephotonics argues that the construction of "fusion" should not include "composite" because the claims "already require that image data from Tele and Wide cameras be 'combined … to provide a fused output image." Hart CC Decl. (Dkt. 148_11), ¶ 53. First, this is wrong because as discussed previously, the concept of fusion itself requires combination, and thus a construction of fusion would require including this. But Corephotonics misquotes the claim and skips over words, changing the meaning of the claim. Specifically, the claim requires "the camera controller configured **to combine in still mode at least some of the Wide and Tele image data** *to provide a fused output image* … ." '291 Patent, claim 1. Thus, one limitation is "to combine in still mode at least some of the Wide and Tele image data," which specifies when the combination must occur (in still mode) and what must be combined (Wide and Tele image data). A second requirement of the claim is "to provide a fused output image," which specifies that there must be an output of a fused output image. Thus, even if the "to combine" phrase was not in the claim, the

"to provide a fused output image" already requires combining image pixel values from multiple images.

ii. Corephotonics Arguments Are Based on an Overly Narrow Reading of Apple's Proposed Constructions.

102. Corephotonics takes an overly narrow view of Apple's proposed construction. Apple construction does not require "replacing pixels from one image with pixels from another image" as Corephotonics argues. Corephotonics Brief, at 10. Rather, Apple's construction requires including the pixels from both to create a composite image, the well understood meaning to a POSITA.

103. A pixel in a color image is a spatial location on an image that has a particular color and brightness. The representation of the color and brightness for a pixel generally requires three values. For example, a pixel can be represented as an "RGB" value, where the three values represent the red, green, and blue components of the pixel, and the brightness component is included within those values. A YCrCb) image is made up of values representing the luminance (Y) and colors (Cr, Cb). Other color spaces include YUV, CIE, XYZ, and a greyscale image has a single channel (one value per pixel). A POSITA may translate between these representations using well understood algorithms.

104. Apple's construction of fusion requires a combining of pixel values from the two images. Therefore, assume an RGB pixel in the Wide image has values (10, 50, 80), and a pixel in the Tele image has RGB values (30, 70, 100). A pixel in the output image could be created in which the RGB values are the average of those two pixels, i.e., with values (20, 60, 90).[7] A system performing such an algorithm would fall within Apple's construction of fusion, as it is a composite that includes pixels from the Wide and Tele images (i.e., combines pixel values from Wide and Tele). Similarly, a system that combines the luma (luminance) from one image with the chroma (chrominance) in another image also falls under Apple's proposed construction. Another way to state this might be that fusion requires combining pixels from the Wide and Tele images, and a

[7] That is, RGB pixel (10, 50, 80) averaged with RGB pixel (30, 70, 100), which is ((10+30)/2, (50+70)/2, (80+100)/2), which results in RGB pixel (20, 60, 90).

fused output image is one with a combination of pixels from the Wide and Tele images. Under this proper understanding of Apple's construction, it is clear that it is a false premise that Apple's construction requires "replacing pixels from one image with pixels from another image,"

105. Corephotonics argues that fusion is a "genus term," that Apple's proposal would select only one particular species, and that there has been no "disclaimer or disavowal of the term's ordinary meaning." (Brief, at 9.) Corephotonics provides no evidence other than the say-so of its expert that there is an "ordinary meaning" of fusion that means anything other than combining pixel values from two images. It provides no examples of fusion that do not fall within what it calls the "species" of combining pixels. Apple's construction would include all examples of fusion in the patent, in the prior art, and cited by Corephotonics, which all combine pixel values from two images, as discussed further below. Moreover, Corephotonics has repeatedly disclaimed various combinations of information from two images as not constituting fusion, as I discuss below.

106. Corephotonics also argues that fusion merely requires "combining information from two images" not "the combination of pixels" from two images. Corephotonics Op. CC Brief, at 9 ("'Fusion' simply requires, as Corephotonics proposal conveys, combining information from two images. The concept of fusion may include the combination of pixels (as was disclosed in the prior art cited by the '291 patent, but a POSITA would not understand fusion to be limited in that way.") I disagree that a POSITA would understand the concept of fusion to be anything other than combining pixels from two images. Corephotonics does not provide a single example in which the term "fusion" is used to mean combining any information other than pixel values from anywhere in the art. Rather, as discussed below, everything cited by both parties (and every reference of which I am aware) uses fusion to refer to combining pixels from two images.

107. Corephotonics next argues that the embodiment shown in Figure 5 of the '291 Patent (discussed above) would not fall within Apple's construction of fusion, and thus Apple's proposed construction would improperly exclude a preferred embodiment. (Corephotonics Brief, at 13.) Corephotonics argues that the fused image described in Figure 5, step 512 does not fuse Wide image pixels and ***Tele image pixels***, but instead fuses Wide image pixels and ***resampled Tele image pixels***. (See Corephotonics Brief, at 13 ("The 'output image' contemplated by Figure 5's Step 512

has only 'pixels' from the Wide image, whereas the Tele image is resampled before data deriving from resulting resampled image is fused with pixels of the Wide image. It has no 'pixels' from the Tele image. Thus, Apple's proposal, which requires that the fused output image include pixels from both "Wide" and "Tele" images, would improperly exclude the patent's Figure 5 embodiment."). This argument is based on Corephotonics' inaccurate reading of Apple's proposed construction. The proposal does not require that the exact Wide and Tele image pixels are present in the composite image. Rather, it only requires that they are included. In other words, the resampled Tele image pixels that are fused in Figure 5, step 512 include Tele image pixels, and thus Tele image pixels are included in the output. In other words, the Wide and Tele image pixel values are combined to create the pixels of the output image. Thus, Figure 5, step 512 of the '291 Patent is within the scope of Apple's proposed construction, perhaps with the clarification that fusion is creating a composite as a combination of pixel values from the Wide and Tele images. To the extent Corephotonics and Dr. Hart are arguing that use of the Wide image in step 510 is also fusion, that is nonsensical. Fusion does not happen until step 512. If there is an error and the cropped Wide image is used in step 510, that is not called fusion in the '291 patent and would not be considered fusion by a POSITA.

108. Corephotonics also argues that using the terms Wide and Tele in the construction of fusion results in nonsensical phrases such as for "Tele imag[es]." The claim refers to "Tele image data." Second, Corephotonics' construction of Wide and Tele would likewise result in nonsensical phrases if the claim constructions are merely put into the claim language. For example, "Tele image data" would be "one of a pair of imaging sections with a narrower field of view image data." Both Apple's and Corephotonics' proposals require reading the phrases that use the term "Wide" and "Tele" to be read in context. The claim already requires that Tele image data is obtained from a Tele imaging section. Under Apple's construction, the Tele image data is image data from the imaging section with the TTL/EFL less than 1.0. This makes perfect sense to from the perspective of a POSITA.

109. Corephotonics next argues that Apple's inclusion of "Wide and Tele" in the proposed construction of "fusion" results in redundancy. However, Corephotonics provides no

example in the specification where fusion in the context of the '291 patent means anything other than combining Wide and Tele image data. If anything, this clarifies a POSITA's understanding that the output image that is provided by the camera controller is one that fuses (i.e., combines pixels from) the Wide and Tele images.

110. Corephotonics also argues that with Apple's construction of "image data" as representing pixels, the claim language would be repetitive and unwieldy. Hart CC Decl. (Dkt. 148_11), ¶ 56. To the contrary, the description with Apple's proposed constructions makes it very clear what the claim requires a camera controller:

> (1) to combine in still mode at least some of the Wide and Tele data that represents pixels (2) to provide a composite output image that includes pixels from the Wide and Tele images of the object or scene from a particular point of view and (3) to provide continuous zoom video mode output images that do not include a composite image that includes pixels from the Wide and Tele images of the object or scene

Id. (modified to include the "continuous zoom video mode" language omitted from Corephotonics' argument.

111. Finally, Corephotonics argues that Apple previously admitted that fusion involved combining information from two images, not combining pixels from two images. Neither Corephotonics or Dr. Hart provide a citation for this proposition. Corephotonics notes that Apple previously stated that "a fused output image" would "at least include an output image including information from two images." However, it is clear that Apple and its expert there, Dr. Cossairt, applied a construction in which the image information constitutes pixel values. In mapping the claim term "fusion" to the prior art, Apple noted that prior art reference Parulski "describes that the primary and secondary image may be combined, for example, 'by **<u>replacing portions</u>** of the primary image with portions of the secondary image," or 'by **considering <u>the pixel values</u>** <u>of both</u> the primary and secondary images." Petition at 40-41 (emphasis in original). To the extent any argument by Apple in its petition could be read to mean that mere combination of "information" other than pixel values is fusion, Corephotonics made clear to a POSITA that its claims do not cover such a broad scope by repeatedly arguing that nothing in Parulski discloses fusion as discussed further below.

iii. All Examples of "Fusion" Provided by Corephotonics Fall Within Apple's Proposed Construction.

112. Corephotonics and Dr. Hart argue that in prior art cited by the '291 patent, "the concept of 'fusion' in digital image processing plainly encompasses techniques that do not combine pixels from two images, such as extracting color information (as opposed to actual pixels) from one image and combining it with another, grayscale, image." (Corephotonics Brief, at 10.) Corephotonics goes on to provide examples from two prior art references cited by the '291 patent: U.S. Patent App. Pub. 2012/0026366 (Golan '366) and WO2015/015383 (Shabtay '383). Based on these examples, they argue that Apple's construction is incorrect.

113. Corephotonics is wrong. Both Golan '366 and Shabtay '383 use the term fusion to refer to techniques that fall with Apple's construction of fusion. That is, they both use the term to refer to techniques that combine pixel values from two images.

114. Golan '366 uses the term fusion in its plain and ordinary meaning to a POSITA to mean combining pixels from two images to create an output image. In the embodiment discussed by Dr. Hart, Golan discloses a camera system 600 with a color image sensor 612 with a wide FOV and a monochrome image sensor 610 having narrow FOV 640. *Id.*, Para 64. Golan '366 explains that "[a] principal intention of the present invention includes providing a camera system 600 and a method of use thereof, wherein the output image frame 650 has the resolution of image sensor 610, having narrow FOV 640, and the color of image sensor 612, having wide FOV 642." *Id.*, ¶ 65. These elements of the camera system 600 are shown in Figure 6 below:

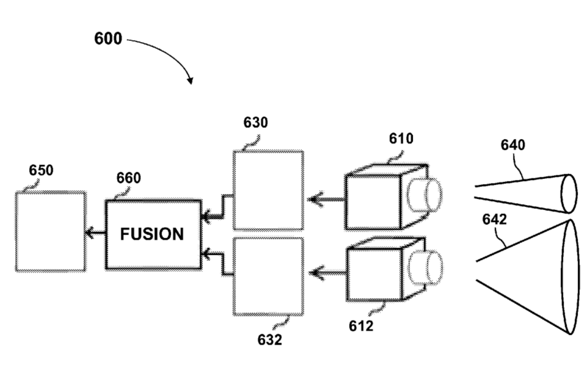


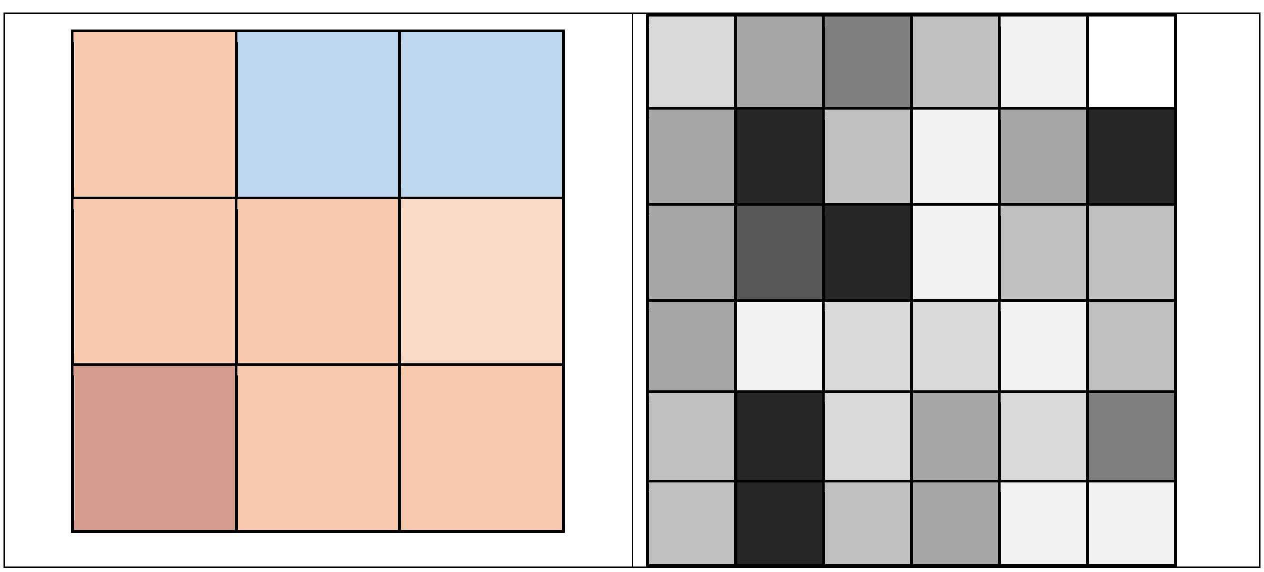
Fig 6

115. Golan '366 describes the fusion of color and monochrome information in Figure 6

as follows:

> ***Fusion module 660 extracts the color information from color image frame 632 and fuses the extracted color information with monochrome image frame 630 to form a high resolution, colored image frame 650. The fusion includes computing color values for the high resolution pixels of monochrome image frame 630 from the respective low resolution color image frame 632.*** Preferably, the computation and alignment of the color values is performed in sub pixel accuracy.

Golan '366, at [0067]. Because image frame 630 is monochrome, each pixel has only a single value representing the luminance. The colored image frame 650, on the other hand, has full color values represented in some format, such as RGB or YCrCb. The fusion module 660 "extracts the color information from color image 632 and fuses the extracted color information with monochrome image frame 630." *Id.*, Extracting the color information from an RGB image requires converting it to another format such as YCrCb in which the color information Cr and Cb are separate from the brightness information Y. Then, the extracted color Cr and Cb can be combined with the luminance values from the monochrome image 630. Because the two images are of different resolution and field of view, the fusion requires "alignment" of the color values with the monochrome image, and "computation" of the color values for the output image. For a simplified example, the pixels in the color image 650 may be the colored blocks below, while the pixels in the monochrome image 630 are the monochrome pixels below.



The color pixels are much bigger because they are lower resolution. Golan '366, at [0067] ("The fusion includes computing color values for the high resolution pixels of monochrome image frame 630 from the respective low resolution color image frame 632.") The color pixels need to be aligned and interpolated to determine the values they will take when combined with the monochrome image pixels.

116. Golan '366 explains that the conversion of the pixel values back to RGB for the output image 650 may be performed in the fusion module 660 or, as shown in Figure 7, in a dedicated module:

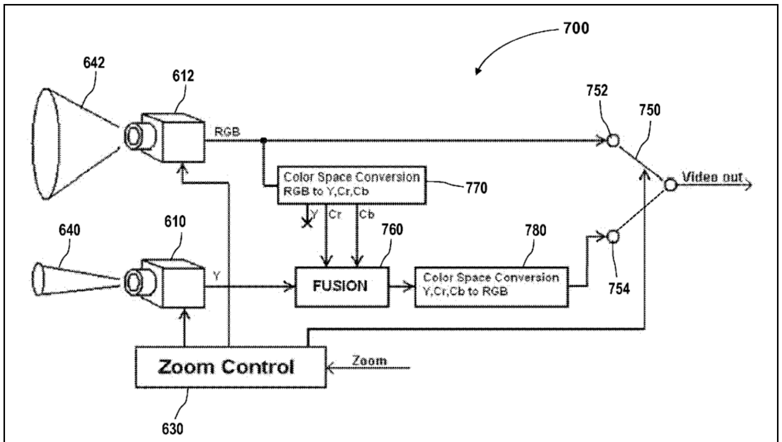


Fig 7

> ***In some variations of the present invention, the output colored image frame 650 is provided with RGB information*** [as shown in Golan '366, Figure 6]**.** In other variations of the present invention [as shown in Golan '366, Figure 7], fusion module 760 transmits the Y information, obtained from monochrome image sensor 610 covered with color (Cr, Cb) information obtained from color image sensor 612. The color information obtained from color image sensor 612 via a color space. Then, fusion module 760 merges the Y information, obtained from monochrome image sensor 610, and the color (Cr, Cb) information. ***Then, color space conversion module 770 converts the image back to an RGB color space, creating colored output image frame 650.***

Golan '366, at [0068]. Thus, as shown above, the Golan '366 prior art uses the term fusion as would be understood by a POSITA and consistent with Apple's construction to mean that pixels from the two images are combined. The values of the color pixels from the color image are used to determine color vales, and then those values are combined with luminance values from the

monochrome image. *Id.* Corephotonics argues that Golan's use of the term "fusion" would not fall within Apple's construction, because it does not involve "replacing pixels from one image with pixels from another image or involve a requirement that pixels from both images always be included in the output image." Hart CC Decl. (Dkt. 148_11), at ¶ 46. But as explained above, Apple's construction does not require replacing pixels from one image with pixels from the other. As for involving a requirement that pixels from both images are always included in the output image, that is required for fusion. Fusion requires that pixel values from both images are combined into the output. All of Golan's references to fusion do precisely that – combine pixel values from both images. Every technique referred to as "fusion" in Golan combines pixel values from both images.

117. Similarly, Corephotonics is incorrect that Apple's construction of fusion excludes Shabtay '383. I note that Shabtay '383 on its face names the same inventors as the '291 patent. Corephotonics alleges that Shabtay '383 refers to several techniques as fusion that would be excluded by Apple's proposed construction. I disagree. Each of the Shabtay '383 techniques discussed by Corephotonics are within Apple's construction. Corephotonics points to a single passage in Shabtay '383 and states that it teaches "feeding two images, each with a given resolution into an image fusion algorithm to produce an image with a greater resolution." Hart CC Decl. (Dkt. 148_11) ¶ 47 (citing Shabtay '383 at 9:9-18). Corephotonics states that this method "creates a new, higher-resolution array of pixels [as the output image], and these new pixel values are determined based on data from both input images." Hart CC Decl. (Dkt. 148_11) ¶ 47.

118. First, Corephotonics' argument that this disclosure in Shabtay '383 does not fall within Apple's construction again rests on the faulty premise that Apple's construction requires the same exact pixels from the Wide and Tele images to be in the output image. But the construction requires including the pixels in the composite image, which, of course, could be based on some combination of the pixels from the Wide and Tele image. Therefore, the real question is, does Shabtay '383 uses the term fusion to mean generating a composite image by including pixels from both Wide and Tele images (i.e., combining pixel values from Wide and Tele images), as proposed by Apple. As explained below, it does.

119. Second, turning to Shabtay's disclosure, it is clear that it uses the term "fusion" – consistent with the '291 patent, the knowledge of a POSITA, and every cited reference in this proceeding – to mean forming a composite image by including pixels from both images. I note that Corephotonics explanation of Shabtay '383 fusion obscures what is actually taught in Shabtay '383 by stating that a "***higher-resolution array of pixels*** [as the output image], and these new pixel values are determined based on ***data*** from both input images." The output pixels are determined based on some unknown "data" from the two input images, rather the output is based on the pixels from the two input images.

120. Like Golan, Shabtay '383 combines a color image with a luminance image, but from cameras having substantially the same field of view rather than Wide and Tele, as disclosed in Golan:

> In various embodiments, there are provided dual-aperture digital cameras with auto-focus (AF) for imaging an object or scene, each such dual-aperture digital camera comprising a first sub-camera that includes a first optics bloc and a color image sensor with a first number of pixels, the ***first camera operative to provide a color image*** of the object or scene, a second sub-camera that includes a second optics bloc and a clear image sensor having a second number of pixels, the ***second sub-camera operative to provide a luminance image*** of the object or scene, ***the first and second sub-cameras having substantially the same field of view***, an AF mechanism coupled mechanically at least to the first optics bloc, and a camera controller coupled to the AF mechanism and to the two image sensors and configured to control the AF mechanism, to calculate a scaling difference and a sharpness difference between the color and luminance images, the scaling and sharpness differences being due to the AF mechanism, and to ***process the color and luminance images into a fused color image*** using the calculated differences.

Shabtay '383, 4:18-30. The color and luminance images are combined into the output image:

> ***A digital image processing algorithm combines the two images into one image, in a process called "image fusion". Henceforth, the algorithm performing this process is called "image fusion algorithm"*** The resulting image may have a higher resolution (in terms of image pixels) and/or a higher "effective resolution" (in terms of the ability to resolve spatial frequencies in the scene, higher "effective resolution" meaning the ability to resolve higher spatial frequencies) and/or a higher SNR than that of one sub-camera image.
>
> In terms of resolution and exemplarily, if each sub-camera produces a 5 megapixel (2592×1944 pixels) image, the image fusion algorithm may combine the two images to produce one image with 8 megapixel

> (3264×2448 pixels) resolution. ***In terms of effective resolution, assuming that an imaged object or scene includes spatial frequencies, the use of a dual-aperture camera having a clear sensor and a color sensor as disclosed herein leads to an overall increase in effective resolution because of the ability of the clear sensor to resolve higher spatial frequencies of the luminance component of the scene, compared with a color sensor. The fusion of the color and clear images as performed in a method disclosed herein*** (see below) adds information in spatial frequencies which are higher than what could be captured by a color (e.g. Bayer) sub-camera.

Id., 9:9-25.

121. In each embodiment, Shabtay '383 performs fusion by combining pixels from the two images into a composite output image. For example, in the embodiment in Figure 4, in step 402, "the ISP generates a full color image, with R, G, B values at each image pixel;" at step 404, images are "normalized … by subtracting the mean from each pixel and dividing each pixel by the standard deviation in each image. … to create an output image with greater resolution; step 406 performs "local registration and parallax correction to estimate a disparity map;" and Step 408 requires "combining [the pixel] information from both images, according to the disparity map." Figures 4A. The disparity map is used in the mapping of pixels from one image to the other while taking into account parallax. It provides fine grained spatial registration. Given that the output is a high resolution image, a POSITA would understand that they need to warp one image according to the disparity map, and then combine the resulting pixels with the reference image pixels. Similarly, Shabtay '383 discloses at Step 508 in Figure 5, performing denoising using fusion. This is a well understood denoising process. Taking the per-pixel average of the values from multiple images results in reducing noise because the multiple images are multiple measurements of the pixel value, the noise essentially cancels out. Shabtay '383 use of the term fusion is therefore consistent with Apple's proposed construction.

iv. Corephotonics' Construction of Fusion Would Encompass Use of Any "Information" From Two Images – The '291 Patent's Use of the Word "Information" Does Not Mean Any Combination of Information is Fusion.

122. Corephotonics states the position that fusing merely requires "combining image information from two images." This construction is overly broad. While a POSITA would

consider fusion to combine pixel values (such as color values and brightness of individual pixels), a POSITA would not consider any use of information from two images to be fusion. For example, a POSITA would not consider use of aggregate information such as the exposure or focus or color histogram used in one image by the other image to be fusion. In fact, people in the field typically use the term "transfer" when describing using this type of information from one image in another image. *See, e.g.,* Reinhard, et al. "Color Transfer Between Images," Applied Perception (Sept. 2001), at 34 (available at https://www.cs.tau.ac.il/~turkel/imagepapers/ColorTransfer.pdf); Liu, "An Overview of Color Transfer and Style Transfer for Images and Video," 2022 (available at https://arxiv.org/abs/2204.13339).

123. Corephotonics and Dr. Hart argue that "When discussing the concept of fusion, the patentees made clear that 'fusion' referred to the combination of image information." Hart CC Decl. (Dkt. 148_11), ¶ 49. However, the only portion of '291 patent cited by Corephotonics and Dr. Hart supporting this statement is this sentence, "In still mode, zoom is achieved 'with fusion' (full or partial), by fusing W and T images, with the resulting fused image including always information from both W and T images." This sentence would not cause a POSITA to think that fusion would take a meaning other than its ordinary meaning in the field or its use throughout the patent as described above. Rather, this sentence means that when zooming while taking photos (i.e., "still mode" versus video), the invention's algorithm requires the resulting fused image will ***always*** have information from both Wide and Tele images. The patent's disclosed embodiment conforms with this understanding – always using either Wide fusion output or Tele fusion output:

> Zoom-In and Zoom-Out in Still Camera Mode
>
> We define the following: TFOV-tan (camera FOV/2). "Low ZF refers to all ZF that comply with ZF<Wide TFOV/Tele TFOV. "High ZF refers to all ZF that comply with ZF>Wide TFOV/Tele TFOV. ZFT1" refers to a ZF that complies with ZF=Wide TFOV/Tele TFOV. In one embodiment, Zoom-in and Zoom-out in still mode is performed as follows:
>
> Zoom-in: at low ZF up to slightly above ZFT, the output image is a digitally zoomed, ***Wide fusion output***. For the up-transfer ZF**, the Tele image is shifted and corrected** by global registration (GR) to achieve smooth transition. Then, the output is transformed to a ***Tele***

> ***fusion output***. For higher (than the up-transfer) ZF, the output is the ***Tele fusion output*** digitally zoomed.
>
> Zoom-out: at high ZF down to slightly below ZFT, the output image is a digitally zoomed, ***Tele fusion output***. For the down-transfer ZF, **the Wide image is shifted** and corrected by GR to achieve smooth transition. Then, the output is transformed to a ***Wide fusion output***. For lower (than the down transfer) ZF, the output is basically the down-transfer ZF output digitally zoomed but with gradually smaller Wide shift correction, until for ZF=1 the output is the unchanged [*i.e.*, unshifted] Wide camera output.
>
> In another embodiment, Zoom-in and Zoom-out in still mode is performed as follows: Zoom-in: at low ZF up to slightly above ZFT, the output image is a digitally Zoomed, ***Wide fusion output***. For the up-transfer ZF and above, the output image is the ***Tele fusion output***.
>
> Zoom-out: at high ZF down to slightly below ZFT, the output image is a digitally Zoomed, ***Tele fusion output***. For the down-transfer ZF and below, the output image is the ***Wide fusion output***.

'291 Patent, 9:44-10:10 (emphasis added). The description shows that in general, when zoomed out, the output is a "Wide fusion output," and when zoomed in, the output is a "Tele fusion output." As previously discussed both a "Wide fusion output" and a "Tele fusion output" combine pixels from both Wide and Tele images. When switching from Wide fusion output to Tele fusion output, the Tele fusion output is shifted to account for parallax between the images. When switching from Tele fusion output to Wide fusion output, the Wide fusion output is shifted for the same reason. When zooming out even further, the shift is gradually reduced, until, when there is no zooming, the Wide output is not shifted. *Id.* (stating that there will be gradually smaller Wide shift correction until it can output the "unchanged Wide camera output").

124. The only example of using only the Wide or Tele image as the output is when there is an error condition. A POSITA would not consider this to alter the understanding that fusion within the '291 Patent always combine both Wide and Tele pixel values, as previously explained. An error condition would not be considered part of the invention.

v. Corephotonics distinguished prior art techniques that combine image information other than pixels, arguing that fusion requires including pixels from the Tele image in the Wide image.

125. In IPR 2020-00905, Corephotonics distinguished prior art from the "fusion" taught

by U.S. Patent No. 10,225,479, on the basis that the prior art methods were not fusion. The '479 Patent issued from a continuation application of the '291 Patent and shares essentially the same specification. Claim 1 of the '479 Patent recites:

> A dual-aperture digital camera for imaging an object or scene, comprising:
>
> a) a **Wide camera** comprising a Wide lens and a Wide image sensor, the Wide camera having a respective field of view FOV_W and being operative to provide a Wide image of the object or scene;
>
> b) a **Tele camera** comprising a Tele lens and a Tele image sensor, the Tele camera having a respective field of view FOV_T narrower than FOV_W and being operative to provide a Tele image of the object or scene, wherein the Tele lens has a respective effective focal length EFL_T and total track length TTL_T fulfilling the condition $EFL_T/TTL_T>1$;
>
> c) a first autofocus (AF) mechanism coupled mechanically to, and used to perform an AF action on the Wide lens;
>
> d) a second AF mechanism coupled mechanically to, and used to perform an AF action on the Tele lens; and
>
> e) **a camera controller** operatively coupled to the first and second AF mechanisms and to the Wide and Tele image sensors and **configured to** control the AF mechanisms and **to process the Wide and Tele images to create a fused image**, wherein areas in the Tele image that are not focused are not combined with the Wide image to create the fused image and wherein the camera controller is further operative to output the fused image with a point of view (POV) of the Wide camera by mapping Tele image pixels to matching pixels within the Wide image.

'479 Patent, claim 1. As shown above, like the '291 patent, the claims included a "Wide camera," a "Tele camera," and a "camera controller … configured … to process the Wide and Tele images to create a fused image." *Id.*

126. In support of Apple's petition for IPR, I opined that U.S. Patent No. 7,859,588 to Parulski, et al. ("Parulski") (Ex. AF) teaches fusion as claimed by the '479 Patent. In response to my opinions regarding the existence of fusion in Parulski, Corephotonics and Dr. Hart took the position that several aspects of Parulski do not teach fusion.[8] Specifically, they took the position that while Parulski combines information from its Wide and Tele cameras, that it does not combine

[8] While I describe the positions as Dr. Hart's positions in my explanations below, both Dr. Hart and Corephotonics took the same positions. I therefore, I may not provide citations to both.

"portions" of those images, does not "import data" from one image to another, and that "pixels from the second image are [not] included, or fused in the first image." Based on these explanations as to what fusion requires, Corephotonics and Dr. Hart argued that there is no fusion in Parulski.[9] A POSITA would understand that Corephotonics was stating the well-known understanding of what is required for fusion, such as combining portion of images and including pixels from one into another. However, Corephotonics' current broad construction appears to seek to include combinations of information that were explicitly distinguished in Parulski.

127. I will walk through the various embodiments that Dr. Hart distinguished as not showing fusion, show that each of those would be fusion under the currently proposed broad construction, and that Dr. Hart's language distinguishing these embodiments confirm a POSITA's understanding that processes that merely combine information, do not perform fusion. I understand that by distinguishing these embodiments, Corephotonics has also disclaimed the claim scope that is distinguished.

128. As a preliminary, I include Dr. Hart's description of the Parulski reference:

> Parulski uses Figure 1 reproduced below to illustrate an "image capture assembly" including "two imaging stages 1 and 2." *Id.* at 12:42-43. The image capture stages 1 and 2 comprise the zoom lenses 3 and 4 and the image sensors 12 and 14… ." *Id.* at 12:66-67. Lenses 3 and 4 "have different focal lengths to provide and extended optical zoom range for the image capture assembly." *Id.* at 10:15-17.

---

[9] I disagree with Corephotonics and Dr. Hart that Parulski does not disclose fusion, because I have a difference of opinion as to how the embodiments in Parulski would be understood by a POSITA. In my opinion, a POSITA would understand Parulski to be teaching that its range map can be used to identify portions of the image at different distances, and would then combine portions of the images (including their pixels) at different distances. In my opinion, for example, Parulski's example in column 22 teaches that photos can be taken with the Wide camera focused on the background mountains and the Tele camera focused on a nearby dog. The two photos can be used to create a range map detailing distances to objects in the scene. The dog can then be extracted from the Tele image and fused into the Wide image to create an image in which both the background mountains and the foreground dog are in focus, broadening the depth of field. Thus, in my opinion, Parulski discloses fusion under a proper construction of that term to mean combining pixel values from the Wide and Tele images. Dr. Hart, on the other hand, does not believe that Parulski teaches combining portions of the Wide and Tele images. He opined that the various uses of information from one image to improve the other image taught by Parulski do not disclose fusion. I agree that those uses are not fusion. Applying his statements to the claim construction of fusion, fusion cannot be merely the combining of information from two images.

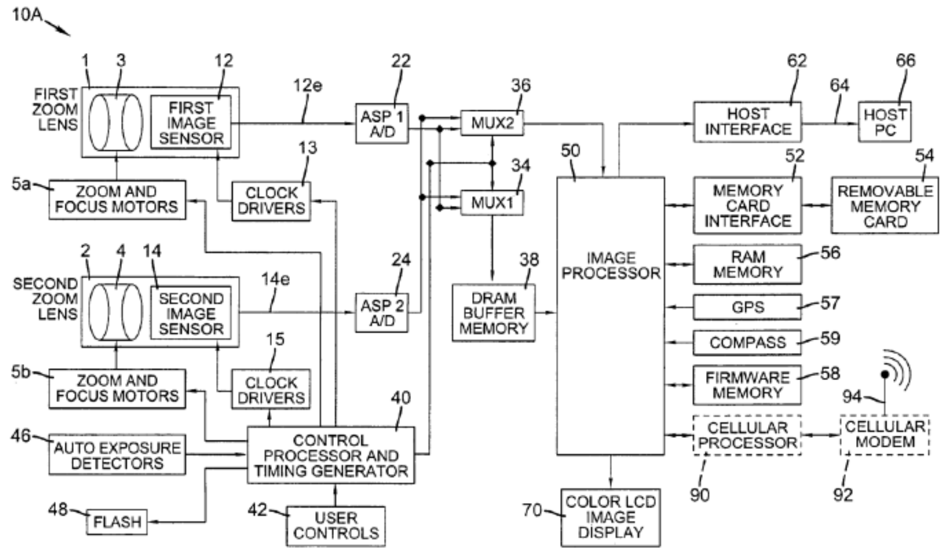


FIG. 1

> Parulski discloses that this design can facilitate autofocusing. "The control processor and timing generator 40 controls the digital multiplexers 34 and 36 in order to select one of the sensor outputs (12e or 14e) as the captured image signal, and to select the other sensor output (14e or 12e) as the autofocus image signal." *Id.* at 14:1-5. "Briefly summarized, the image processor 50 produces the focus detection signals that drive the first and second focus adjusters, that is, the zoom and focus motors 5a and 5b."

Hard Decl.

129. With this introduction, Dr. Hart discusses various embodiments in Parulski, and opines that they do not teach fusion.

130. ***First,*** Dr. Hart argued that Figures 3 and 8 of Parulski do not teach fusion. "Fig. 3 depicts a flow diagram showing a method ***for performing autofocus and for capturing digital still images*** according to a first embodiment of the digital camera shown in Fig. 1" and "Fig. 8 depicts a flow diagram showing a method ***for*** performing ***autofocus and for capturing digital video images*** according to a first embodiment of the digital camera shown in Fig. 1[.]" Parulski, 8:34-37, 8:48-51. Because still images are at issue here, I will focus on Figure 3, which I reproduce below.

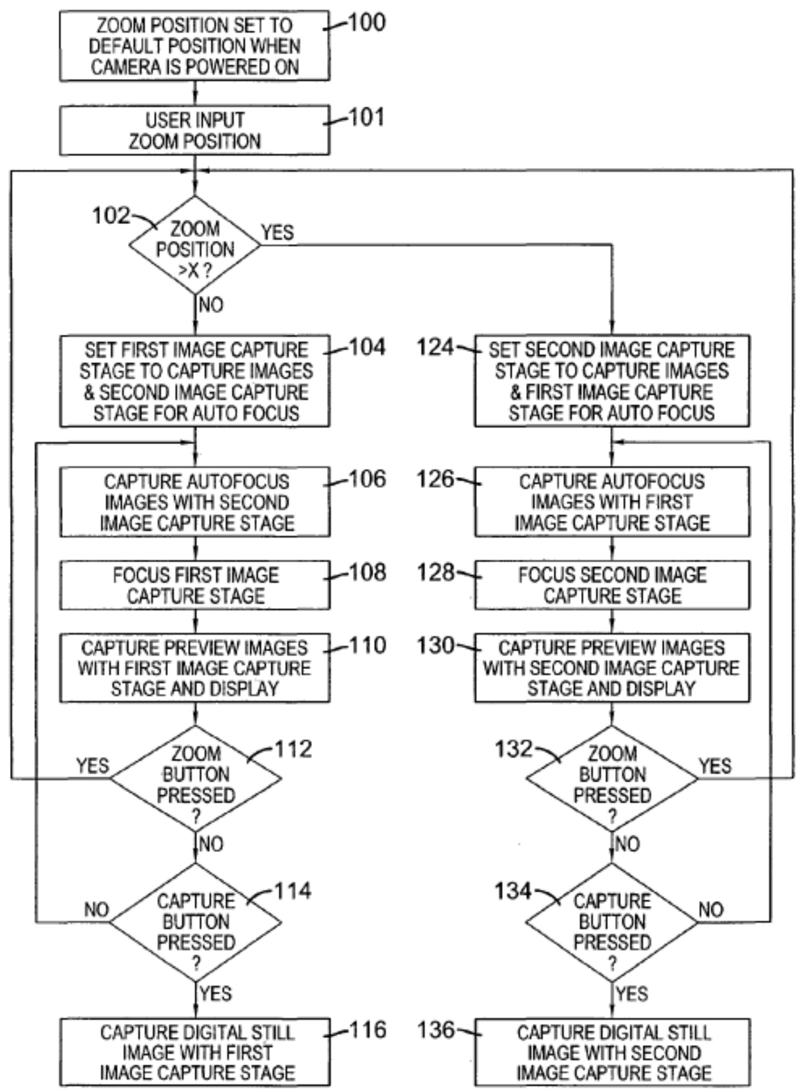


FIG. 3

Parulski, Fig. 3. The specification describes Figure 3 as follows:

> As part of composing the images, in block 102 the user typically presses the zoom button 42c in order to set a desired field of view for the digital camera 10A. In block 104, if the zoom position setting is less than X (a negative response to block 102), then the first image capture stage 1 is used to capture images in the preview mode, while ***the second image capture stage 2 is used to capture autofocus images.*** The first image capture stage 1 continues to capture images or preview on the display 70 (block 110) while, in block 106, ***the second image capture stage 2 is used to capture autofocus images for autofocus of the first image capture stage 1, which are processed by the image processor 50 and used in block 108 to focus the first image capture stage***. In block 112, if the zoom button 42c is not pressed, and in block 114 if the capture button is pressed, a digital image is captured in block 116 with the first image capture stage 1.

Parulski, 15:51-67.

131. Dr. Hart described Figure 3 as follows:

> 57. The decision at block 102 uses the zoom position to determine whether the first stage (image capture stage 1 in Fig. 1) or the second stage (image capture stage 2 in Fig. 1) has the more appropriate focal length for that zoom setting. As an example, we can assume that the zoom position is not greater than X and the steps on the left hand side of Fig. 3 starting with 104 are selected, previewing images from the first stage and using the second stage to assist the autofocus of the first stage.2
>
> 58. Block 108 represents the step in Fig. 3 that represents the action of the image processor (block 50 in Fig. 1) that accesses the images captured by both stage 1 and stage 2. "In block 104 … the first image capture stage 1 is used to capture images in the preview mode, while the second image capture stage 2 is used to capture autofocus images. The first image capture stage 1 continues to capture images for preview on the display 70 (block 110) while, in block 106, the second image capture stage 2 is used to capture autofocus images for autofocus of the first image capture stage 1, which are processed by the image processor 50 and used in block 108 to focus the first image capture stage 1." *Id.* at 15:57-67.

Hart Decl. Paras 57-58.

132. How the second image capture stage information is used for autofocus is described with respect to other flow charts, such as Figures 4 and 5. "A flow chart of an autofocus process using the two image capture stages shown in FIG. 3 in a rangefinder configuration is shown in FIG. 4, where the rangefinder method is used in blocks 108 and128 of FIG. 3 to autofocus the images from the first and second image capture stages," and "A flow chart of an autofocus process using the two image capture stages shown in FIG. 3 in a well known "hill climb" contrast comparison method is shown in FIG. 5, where the "hill climb" contrast comparison method is used in blocks 108 and 128 of FIG. 3 to autofocus the images from the first and second image capture stages." Parulski, 16:24-28, 17:7-13. These two figures, copied below, again show that information from images from both image capture stages are combined.

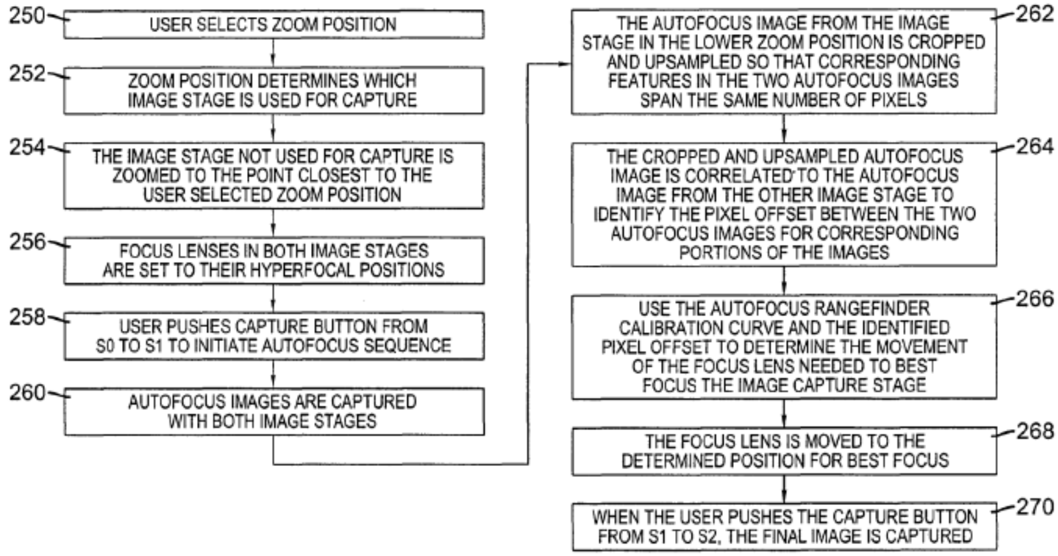


FIG. 4

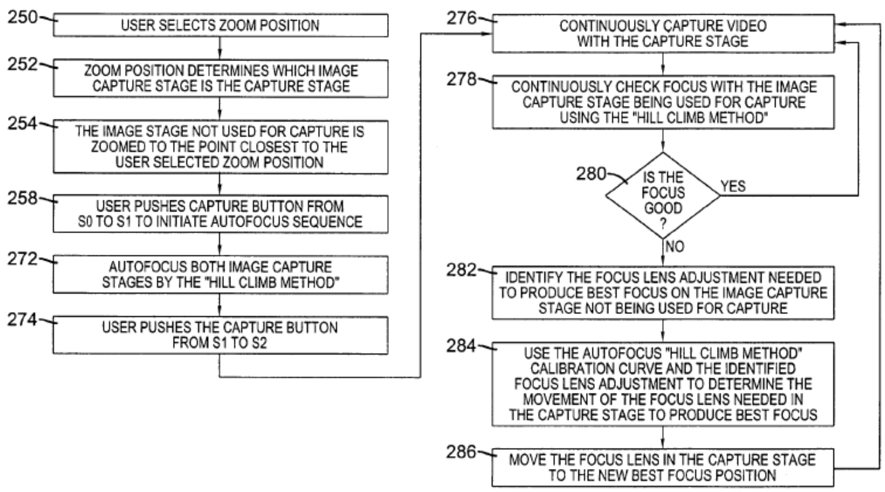


FIG. 5

133. Dr. Hart describes them as follows:

> 60. The "rangefinder" option is shown in Fig. 4, [ ] Step 258 indicates that the shutter button is pressed halfway down (S0 à S1), initiating autofocus. "***The cropped and upsampled autofocus image is then correlated with the other autofocus image to identify the pixel shift between the two autofocus images (block 264) and thereby produce the focus detection signal***." *Id.* at 16:54-58. Step 266 indicates a "rangefinder calibration curve" is used to convert the "focus detection signal" into the single value sent by step 268 to focus the "first image" in block 108 of Fig. 3.
>
> 61. The "hill climbing" option is illustrated in Fig. 5 and disclosed by *Id.* at

> 17:7-56. It uses ***the second capture stage to experimentally adjust its focus to maximize contrast to find the optimal focus setting for the first capture stage***. The advantage of this approach is that the iterated adjustments in the second capture stage can remain hidden while the user observes the preview image updated in the first capture stage, even while adjusting zoom settings or reorienting the camera to different focal points in the scene.

Hart Decl. Paras. 60-61.

134. As described by Dr. Hart and the specification, in Parulski Figures 3 and 8, the first image capture stage takes the photo that becomes the output image. The second image capture stage (i.e., camera) captures autofocus images, which are used to focus the first image capture stage into a focus position that is used to capture that output image. Therefore, the output image is taken from the first image capture stage, and combines some information from images from the second image capture stage – namely, it uses the second image capture stage information to determine how to focus the first image. Figures 4 and 5 above describe methods Parulski describes for using the information from the second image capture stage to determine the focus for the first.

135. A POSITA would not consider this combining of information from multiple images in order to determine the focus of one to be fusion. Dr. Hart agrees with me, having stated, "the image capture assemblies of Figures 3 and 8, [ ] do not fuse data from two different images." (Parulski at 19:49–51.) However, the broad construction that Corephotonics is now using which merely requires "a combination of image information from two images," would cover the autofocus techniques in Parulski Figure 3 that Corephotonics and Dr. Hart explicitly distinguished as not being fusion.

136. ***Second***, Dr. Hart distinguished Parulski's teaching of the use of a range map to modify an image as not being fusion. Parulski teaches that a range map may be constructed by processing images taken using the Wide and Tele cameras, as shown in Figure 11 of Parulski. For example, the Wide image is cropped and upsampled so that corresponding features in the two images span the same numbers of pixels. Parulski, Fig. 11, block 442, 20:3-6. Then, the Tele image and the cropped and upsampled Wide image are correlated to determine the pixel offset between the images for different portions of the images. *Id.*, Fig. 11, block 480, 20:8-11. The

calculated pixel offsets are then converted to distances from the camera, which can then be used to make a map of the distances to different portions of the images. *Id.*, Fig. 11, blocks 482-484, 20:11-15. Thus, the range map is calculated using image data from the two cameras. Therefore, the pixel data within images from the Wide and Tele cameras are processed to create a range map.

137. Parulski goes on to explain that the range map can be used for many purposes, including:

> a) to improve object identification within the image by identifying the continuous boundaries of the object so the shape of the object can be defined;
> b) to enable object extraction from an image by identifying the continuous boundaries of the object so it can be segmented within the image;
> c) to enable motion tracking of objects within multiple images by identifying objects so they can be tracked as the same object between images;
> d) to enable dynamic depth of field images by blurring of portions of the image that correspond to areas of the scene that lie outside of the desired depth of field;
> e) to improve the dynamic range within images by applying gain adjustments to objects as a whole;
> f) to reduce exposure issues introduced by use of a flash by reducing the gain on the portions of the image that correspond to objects in the foreground and increasing the gain on objects in the background;
> g) to improve scene balance within the image by enabling objects in the foreground to be emphasized.

Parulski, 20:54-21:6. In each of these, the range map is used to identify objects, identify objects and the background, or otherwise provide information for us in a further processing step.

138. Dr. Hart stated that even though the range map itself was created using pixel information from two images, "none of the example uses listed in the specification involves 'fusing' or otherwise combining image data from the two images." Hart, ¶ 63. For example, Corephotonics and Dr. Hart state that example (d) above, which refers to blurring is not "fusing two images," but rather merely "digitally blur[ring]" a single image or portions of the image (here with use of the range map to identify portions of the image for blurring). Hart, ¶ 64. Dr. Hart therefore agreed with me then that merely using two images to create data (the range map) that is then used to inform how to modify one of the images is not fusion. Under Corephotonics construction that merely requires the use of image information, it appears that generation of a range map using pixels from

two images, and then using that range map to modify one of the two images to generate an output image, would constitute fusion, as it is the "combination of image information". Dr. Hart and I agree that this should not be the case – such use of a second image is not fusion. Rather, as Dr. Hart said, fusion requires "combining image data from the two images."

139. ***Third***, Dr. Hart distinguished Parulski's use of an "enhancement signal" based on one image to broaden the depth of field of the other. Parulski's Figure 14, reproduced below, "depicts a flow diagram showing a method for enhancing the depth of field of an image by using images from both image capture stages according to an embodiment of the invention." *Id.* at 9:1-4.

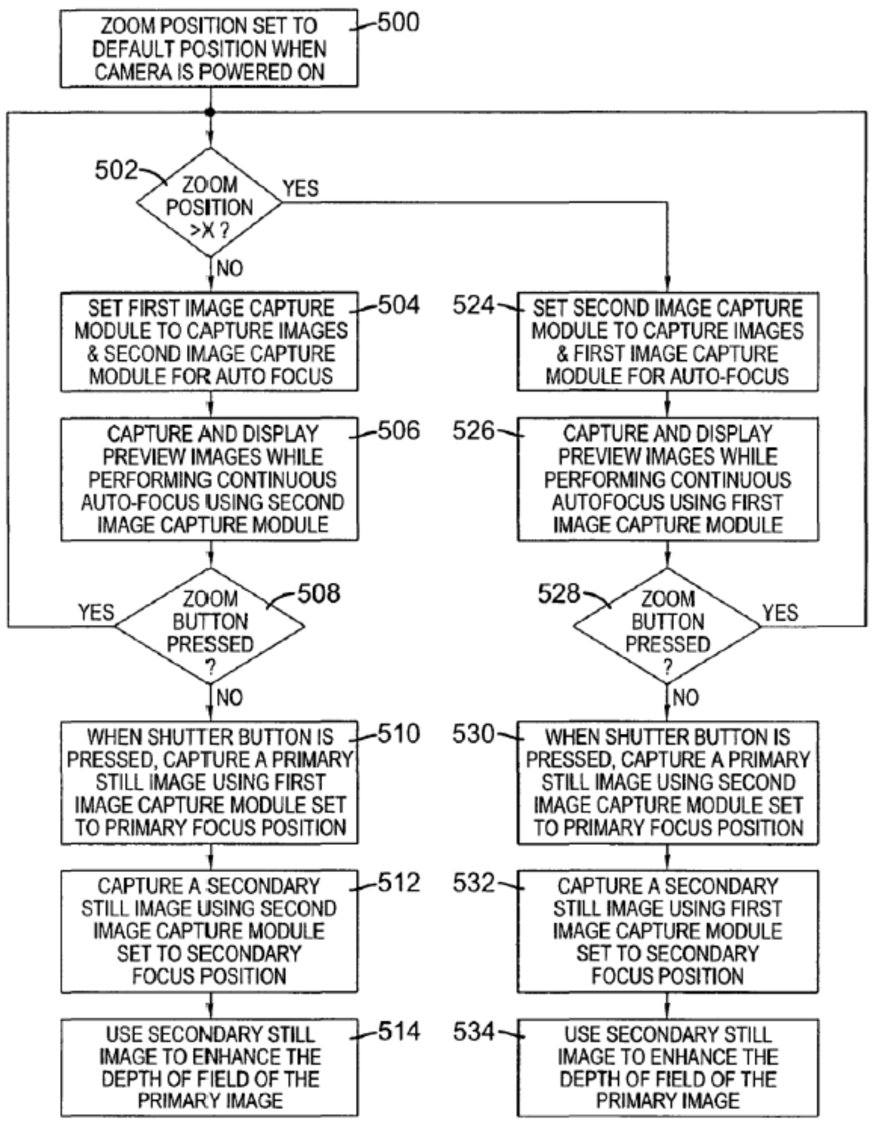


FIG. 14

Parulski, Figure 14. For example, if zoom position is <=X, then Camera 1 is used to capture a Primary image (both 510), the Second Capture Module captures the Second Image (block 512), and the secondary still image is used to enhance the depth of field of the primary image (block 514). Parulski, Figure 14, 22:14-37. The specification explains that the secondary image is used to enhance the depth of field of the primary image by, for example, "provid[ing] an enhancement signal that can be used to sharpen portions of the primary still image that are positioned near the secondary focus distance." *Id.*, 22:37-42.

140. Dr. Hart opined that if Parulski's "enhancement signal" is a range map, "the discussion of Figure 14 in column 22 of Parulski does not describe a '***fused image***,' because sharpening using a range map would involve sharpening the edges ***present in specific portions of the primary still image, rather than transferring image data from the secondary still image into the output image***." (Hart Decl.) ¶ 71. Thus, Dr. Hart distinguished Parulski's Figure 14 on the basis that the use of a range map as an enhancement signal does not show "transferring image data from the secondary still image into the output image."

141. ***Fourth***, Dr. Hart distinguishes the following passage from Parulski which describes "the use of a range map" to modify a picture.

> In order to understand **the use of a range map** for purposes such as noted above, it is helpful to consider an example. Assume that a user/photographer **has a great picture of the Alaskan mountains-beautiful clouded sky and whitecapped mountains in the most distant ranges, flowers carpeting the fields in the mid range, and a black dog sitting in the foreground about 5 feet away**. However, the clouds are blown out (over-exposed), as are the whitecapped mountains. The black dog is too dark (underexposed) and out of focus (because, e.g., the camera was set on landscape mode). **Using the range data, several features of the image can be modified.** The exposure for various locations can be improved by applying gain adjustments to selected object portions of the image: in particular, e.g., to the cloud detail, the snow detail, and the fur on the black dog. More generally**, the range map can be used to improve dynamic range** within the output image by applying gain adjustments to objects as a whole within the output image, and independently of their position in the range map. Moreover, **the depth of field can be adjusted so that, e.g., the dog is in focus, the mountains are in focus and so are those great flowers**. Or, if the user really wants to emphasize the dog more than the beautiful scenery, **the range data can be used to isolate the**

> **mountains and the flowers, which can then be blurred, and further to isolate the dog, which is sharpened to obtain a nice sharp image**. As can be understood, given the availability of a range map according to the invention, there are numerous other uses that would be available for artistically optimizing the image. For instance, **the user can make a dynamic depth of field, that is, with mixed regions of the ranges in focus**. More generally**, the range map can be used to enable dynamic depth of field images by blurring portions of the output image, independently of their position in the range map, that correspond to areas of the scene that lie outside of a desired depth of field for a featured portion of the image.** For example, the dog and mountains, albeit they are at opposite range extremes, could be brought in focus because they are the regions of interest and the flowers in the mid range can be blurred smoothly.

Id., 21:7-44.

142. Dr. Hart stated that this passage does not disclose image fusion, because "nothing in the passage describes **combining portions of the wide and tele images**." (Hart POR Decl.), Para 74-75. Thus, Dr. Hart clearly stated, as I have opined, that fusion requires "combining portions of the wide and tele images." Portions of the wide and tele images – that is, their pixels – have to be combined. Corephotonics' proposed claim construction (that merely requires combining "image information") does not require combining portions of the image, and therefore does not constitute fusion.

143. Dr. Hart further distinguished the embodiment above, stating:

> ***The paragraph describes a series of modifications to a wide image that can be made without directly incorporating image data from the tele image, or using the tele image for any reason other than generating range data.*** It describes "applying gain adjustments to . . . portions of the image" (*Id.* at 21:17–24), which ***can readily be done directly to the wide image data***. Likewise, "blurring" and "sharpening" can be ***done directly on the wide image data*** (using for example the Fourier transform techniques discussed above), ***without importing image data from elsewhere***. Indeed, the blurring and sharpening described would, in general, need to ***work without importing tele image data***. This is because background objects in the wide image, such as the mountains in Parulski's example will generally extend beyond the area visible in the tele image, and limiting the blurring or sharpening to the regions visible in the tele image would not achieve the results described in Parulski.

Hart POR Decl. ¶ 75.

144. I again agree with Dr. Hart's statements here as to what is required for fusion. A

fusion process must "import" data from one image into the other image. *Id.* In addition, a process that can be "done directly to [one image's] image data … without importing image data from elsewhere" is not fusion. *Id.*

145. Statements in Corephotonics' Patent Owner Preliminary Response similarly distinguish the embodiments in Parulski. Corephotonics explicitly argued that fusion requires pixels from a second image to be "included" in the first image, relying on the same portions of the '291 specification that I used above to show why Apple's construction is correct:

> ***The use of one image to "enhance" or "focus" another does not teach "fusing" two images as claimed by the '479 patent.*** *See* Ex.1001 at 2:25-26 ("The images are then stitched (fused) together to form a composite ("fused") image."); *id.* at 3:47-52 ("In still mode, zoom is achieved 'with fusion' (full or partial), by fusing W and T images, with the resulting fused image including always information from both W and T images." (emphasis added)); *id.* at 3:64-4:3 ("The fused image is processed according to a user zoom factor request. As part of the fusion procedure, up-sampling may be applied on one or both of the grabbed images to scale it to the image grabbed by the Tele subcamera or to a scale defined by the user."). ***Parulski does not teach that any pixels from the second image are included, or fused, in the first image.***

Ex. J (Corephotonics Patent Owner's Preliminary Response), at 8.

146. To summarize, embodiments that Corephotonics distinguished in Parulski as not being fusion include:

- Using a secondary image to help determine a setting used to capture or modify a primary image, such as autofocus position or an enhancement signal that is then used to capture the output image using one camera. (see discussions regarding Figures 8 and 14 above)
- Using images from both cameras to create a range map that can be used in various ways to improve the image taken with one camera. (see discussions regarding figure 11 above)
- Modifying pixels already "present in specific portions of the primary still image, rather than ***transferring image data from the secondary still image into the output image***." (see discussion of Figure 14 above)
- Making modifications "directly" to the pixels of one image (such as blurring pixels) based on information that has been determined using the other image (such as a range map), but

"without importing image data" from the other image. (see discussion above of passage in column 21 of Parulski)

147. Based on Corephotonics' statements, image processing processes that Corephotonics admits are not fusion are:

- Processes that do not have "pixels from the second image [ ] included, or fused, in the first image. Ex. J (Corephotonics Patent Owner's Preliminary Response), at 8.
- Processes that do not "directly incorporate[e] image data from the [first] image" into the second
- Processes that do not "transfer[ ] image data from the secondary still image into the output image" in addition to the first image data
- Processes that make modifications "directly" to the pixels of one image, "without importing image data" from the other image

vi. Dr. Hart's alleged prior work in fusion confirms Corephotonics' overly broad definition of the term to a POSITA – Dr. Hart's own publications did not refer to those techniques as fusion.

148. Dr. Hart states that he has worked on "a variety of methods and systems for the fusion of photographs." Hart CC Decl. (Dkt. 148_11), ¶ 11. These references support my opinions – either they do not involve combining pixel values from multiple images and don't refer to their techniques as fusion, or they do involve combining pixel values from multiple image and DO refer to their techniques as fusion.

149. First Dr. Hart identifies U.S. Patent No. 7,365,744, titled "Method and Systems for Image Modification, and describes it as being "on techniques for learning a surface appearance from one photograph and realistically applying it to a different surface in another photograph." Hart CC Decl. (Dkt. 148_11), ¶ 11. This patent does not use the term fusion, which makes sense, because a POSITA would not consider the techniques described to the fusion.

150. Second, Dr. Hart describes use of fusion as part of the National Science Foundation's Digitization of Biodiversity Collections to design and deliver an imaging infrastructure to scan the nation's entomological collections of insect drawers. This project involved "fusion" of photos of small portions of insect drawers, vials, and slides to make the

collections available … as high-resolution zoomable composite images." Hart CC Decl. (Dkt. 148_11) ¶ 12. Referring to a publication on this work, shows that the multiple images of an insect drawers were "'stitched' together into a single 'panoramic' image. This stitching operation is enabled by recent advances in computer vision, and relies on finding matching features in the overlapping regions shared by neighboring images." Dietrich, Hart, et al., "InvertNet: a new paradigm for digital access to invertebrate collections," at 169. I agree that stitching images together is a form of fusion. Indeed, the '291 patent states that images that are stitched together are fused. 2:14-15 ("The images are stitched (fused) together to form a composite ('fused') image.") This example of fusion (stitching) is consistent with Apple's proposed construction, because stitching combines pixel values from multiple images into the output image.

151. Third, Dr. Hart discusses his work on overlaying text on a video screen. Hart CC Decl. (Dkt. 148_11), ¶ 13. A POSITA would not consider performing such an overlay to fall within the concept of "image fusion," because text is not an image. Indeed, within the context of the claims, text is not an image because it would not be output from a camera capturing an image with a lens and image sensor. Thus, this example from Dr. Hart doesn't even fall within Corephotonics' definition of fusion, because overlaying text on an image does not use information from two images. Even if text rendered into a raster representation were considered to be an image in another context, the overlay would not be considered fusion because fusion is understood by a POSITA to be a combination of multiple images of the same scene.

vii. "Fused output image" and "without fusion … output image" are output images that were created using fusion or not created using fusion, and thus their construction is determined by the construction of fused/fusion

Term	Corephotonics' Proposal	Apple's Proposal
"fused output image"	output image including a combination of image information from two images.	a composite output image that includes pixels from the Wide and Tele images.
"without fusion . . . output images"	output images not created by combining image information from two images.	output images that do not include a composite image that includes pixels from the Wide and Tele images.

152. I agree with Apple that the terms "fused output image" and "without fusion … output images" would be understood to be output images that are either fused or without fusion, as

previously construed. Corephotonics' construction does not construe the term "output image," merely copying those words into the output. Therefore, the rest of its constructions must be its proposed construction of fused and "without fusion." Corephotonics believes that "fused" is "including a combination of image information from two images," and "without fusion" is "not created by combining image information from two images."

153. The real difference in these constructions is whether a fused output image must have a combination of any information from the two images, or requires a combination of pixel values. This is extensively discussed above. In my opinion, Apple's construction is correct.

C. Image Data

Term	Corephotonics' Proposal	Apple's Proposal
"image data"	plain and ordinary meaning, or, in the alternative if the Court determines a construction is necessary, "data output from an imaging section"	data that represents image pixels

154. I agree with Apple's proposed construction that the term "image data" within the '291 patent means "data that represents image pixels." Looking to the claims that recite "image data," in the '291 patent, it is apparent that it is a digital photograph. The "image data" is provided by an imaging section, that is part of a "zoom digital camera." The imaging section has a lens, sensor, and image signal processor (ISP). As I explained above in the background section, images from sensors that may be cleaned up by an ISP are still represented as pixels.

155. In Apple's construction, the "data that represents" a pixel means the values of the pixel. For example, an image in the RGB color space would be made up of RGB pixels, which each have three values representing, respectively, the red, green, and blue intensities. An image in the YCbCr color space would be made up of YCbCr pixels, each having three values representing the pixel, namely, the luminance (Y), and two chrominance values (Cb and Cr). An image taken with an image sensor with no color filter would have only luminance values representing each pixel.

156. Dr. Hart and Corephotonics misuse various terms related to images in arguing that Apple's construction is overly narrow. ***First***, they argue that the "image data" "may include data that does not 'represent' specific pixels but instead reflects other image-related data such that [sic]

reflecting the luminance or intensity of an image." However, both luminance and intensity ***are*** data that represent specific pixels in the image. As explained above, the intensity of an image pixel is the amount of light that hits the photoelectric material of the image sensor at that pixel location. If there is a color filter, the intensity may represent only the intensity of one color – for example, an R, G, B color filter will generate data with the intensities for those three colors. The intensity information exists in a photographic image on a per-pixel basis. Similarly, the luminance information for an image exists on a per-pixel basis. The luminance is the light intensity received at a pixel with no color filter, and can also be represented as the Y value in the YCbCr color space. Dr. Hart does not explain how luminance or intensity would be represented in any way that is not on a per pixel basis.

157. ***Second***, Dr. Hart points to U.S. Patent App. Pub. 2011/0064327 to Dagher et al., entitled "Image Data Fusion Systems and Methods" ("Dagher"), and argues that it uses the term "image data" in a way that allegedly would not fall within Apple's proposed construction. Hart CC Decl. (Dkt. 148_11), ¶ 64. Specifically, Dr. Hart notes that Dagher uses the term "image data" to refer to an image's luminosity (i.e., luminance) channel and intensity information, and says this is not within Apple's proposed construction because it is information other than the "individual RGB values in an array of pixels." But Apple's proposal has no such limitation limiting the pixel data to RGB values. Luminance and intensity information for an image are represented on a per pixel basis, and thus are data representing a pixel. As explained previously, the "luminance channel (of luminance data)" and "intensity information" are well understood per-pixel information. The luminance channel is the set of all luminance values for the image (such as the Y value in the YCbCr color space or the pixel value in a monochrome image), while "intensity information" can refer to either monochrome or color intensity information.

158. Dagher itself explains that it's disclosure relates to combining pixels when read in context provided outside the narrow portion cited by Dr. Hart. Dagher discloses providing two images that overlap in the scenes that they capture, where the second image is made up of subsets of data, and fusing them by combining the first image with some but not all of the data subsets in the second image. Dagher, Abstract. For example, Dagher discloses the first passage cited by Dr.

Hart:

> In another aspect, the first collection of overlap image data may include a first collection of luminance data, and the selected one of the image data subsets may be a luminance channel (of luminance data) based on luminance as the characteristic of the second collection of overlap image data, and changing of the first collection of overlap image data may include combining the first and second collections of luminance data. Arranging of the second sub-camera may include supplying the second sub-camera as a grayscale camera for providing the luminance channel as being composed of grayscale scaled image data.

Hart CC Decl. (Dkt. 148_11), ¶ 65. Dagher goes on to describe this embodiment:

> [0063] FIG. 8 illustrates an embodiment of a process 332 for fusing tele and wide images. It relies on the principles described above with reference to FIG. 7, but also ***takes advantage of the human eye's increased sensitivity to luminance over chrominance with respect to blending of overlap regions of wide and tele images represented by first and second sets of image data,*** respectively. ***Using only luminance data allows for a decrease in computational demands*** for signal processing and fusion algorithms, and may reduce susceptibility to color effects (e.g., color aliasing) at edges. ***Image sensors often utilize a Red-Green-Blue ("RGB") color filter array ("CFA"), such as a Bayer pattern CFA, for representing a given set of image data as a group using three data subsets corresponding to red, green and blue. There are a number of other available techniques for representing image data as a plurality of image data subsets, and it is often possible to apply well established techniques to convert image data from one representation to another. As one example, in the embodiment exemplified in FIG. 8, both the tele and the wide images are converted from RGB to YUV in a conversion procedure 334. The YUV model defines a set of image data in terms of one luminance (Y) channel and two chrominance channels (U, V),*** and these channels may each be regarded as subsets of a given set of image data. Then, as in previous examples, the wide image data is upsampled and interpolated in an upsampling procedure 336. The step of upsampling/interpolating data from the wide image may occur before or after conversion of RGB to YUV. Data from the Y channel (luminance) of a tele sub-camera may be optionally high-pass filtered (i.e., option B, as indicated by filtering procedure 315, FIG. 8), as described previously. ***The resulting high frequency luminance data from the tele image is fused with the low frequency luminance data from the wide image***, also as described previously. Optionally, as part of signal processing of the second set of image data, a gain procedure 340 may also be applied to the high frequency data extracted from the tele image prior to fusion with the low frequency data from the wide image. This process is a form of an unsharp mask process. ***Finally,***

> ***chrominance data from the wide image may be returned to form a final, blended image. Alternatively, because chrominance data has been discarded from the tele sub-camera in this embodiment, the tele sub-camera may utilize an image sensor that does not have a color filter array. This allows the tele optical sub-system to utilize its entire sensor area to collect luminance data, resulting in even higher image resolution in the overlap region of the fused image.*** In the example presented above, and as indicated in FIG. 8, chrominance data from the U and V channels (chrominance data), as part of a second set of image data (e.g., the tele image) are discarded as redundant to the U and V data obtained from the wide image. In another embodiment, however, data from the tele U and V channels may be averaged with the U and V data from the wide image to reduce noise.

Ex. AG (Dagher), ¶ 63 (emphasis added). The emphasized portions of this paragraph in Dagher supports the explanation I provided in the Background section of my declaration. Dagher uses the ability to confer image data between color spaces to aid in its fusion method. Specifically, Dagher converts both wide and tele images from RGB to YUV, fuses just the luminance Y channels of both images, uses the U and V chrominance channels from the wide image, and then converts that back to RGB. Dagher notes that "because chrominance data has been discarded from the tele sub-camera in this embodiment, the tele sub-camera may utilize an image sensor that does not have a color filter array. This allows the tele optical sub-system to utilize its entire sensor area to collect luminance data…." As I previously explained, an image sensor with no color filter will calculate just luminance values at each pixel. Dagher's Figure 8 is duplicated below, showing that the original RGB images are made up of N/2 pixels, which are converted to YUV, and then blended into an image with N pixels.

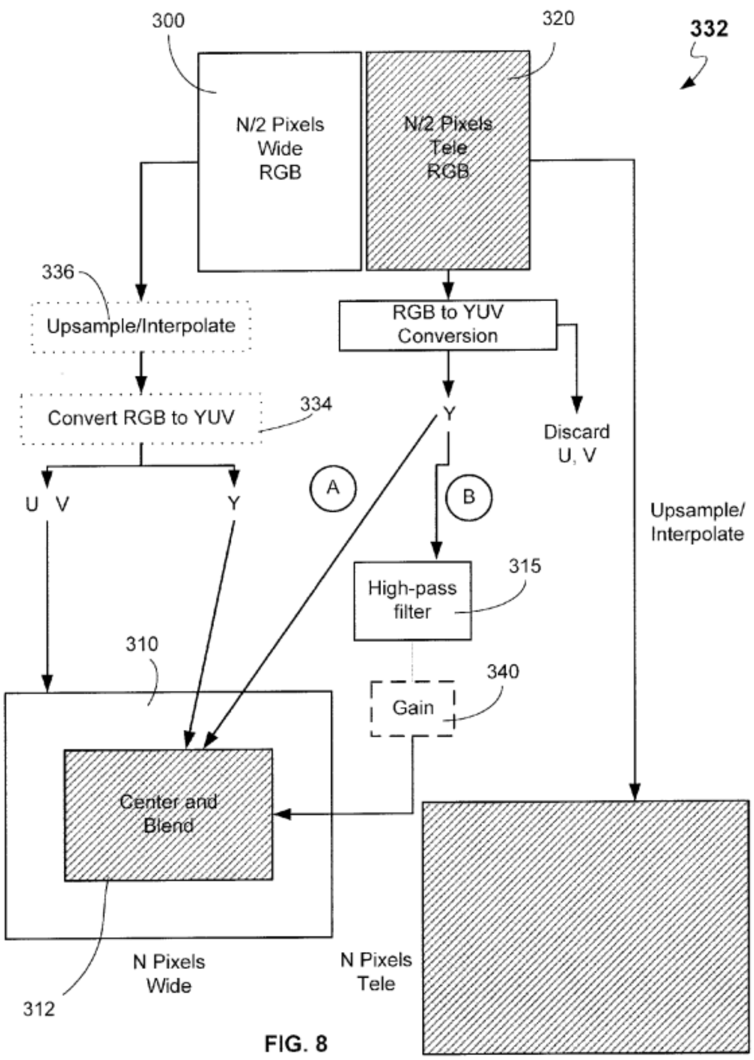


FIG. 8

Id., Figure 8. As further evidence that luminance is a per pixel value, Dagher explains that "FIG. 16 shows two line plots of luminance (i.e., Y channel) intensity as a function of pixel position … ." As is well known in the art, luminance and intensity are clearly data that represent a pixel.

159. The second passage that Dr. Hart cites relates to scaling the intensity values:

> In an additional aspect, the second collection of overlap image data may include intensity information, and scaling the second collection of overlap image data may include changing at least some of the intensity information. In this case scaling the second collection of overlap image data includes applying a gain for causing the changing of the intensity information.

Hart CC Decl. (Dkt. 148_11), ¶ 65. This embodiment is described further in Dagher, which notes that "the (Yc, Uc, Uv) channels may be scaled prior to processing in order to account for any

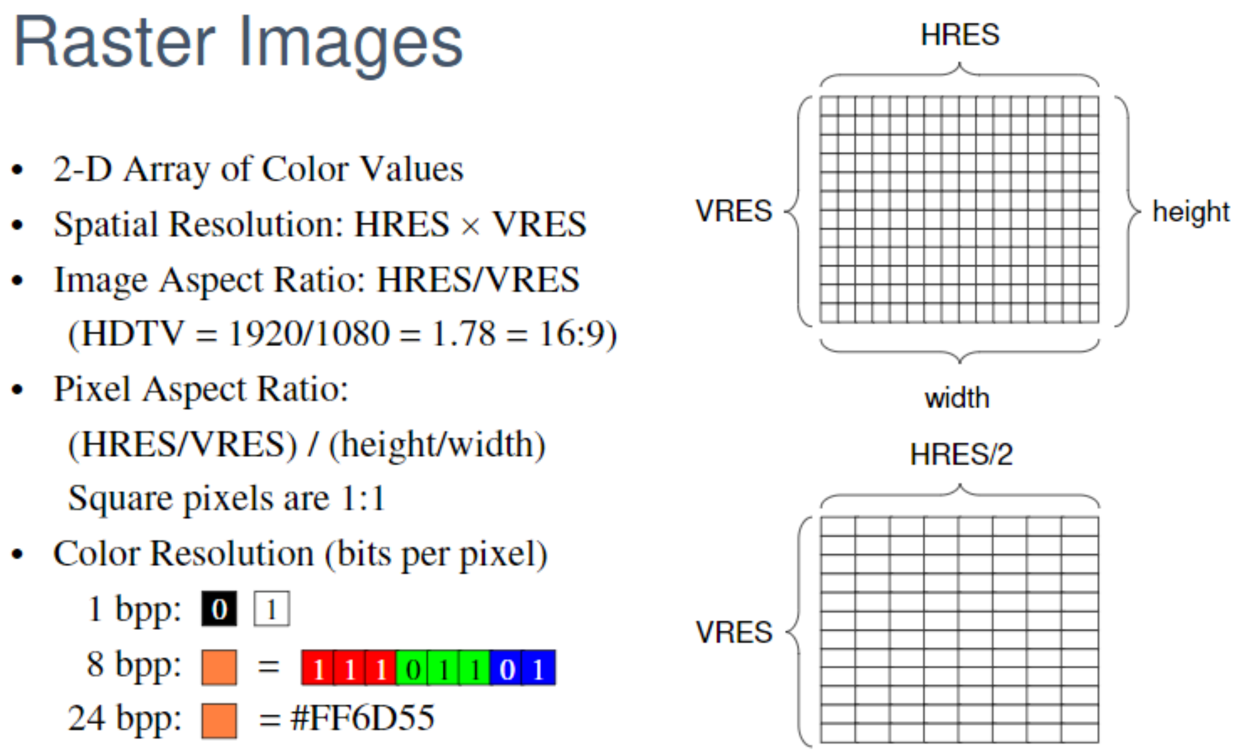
intensity difference between the two sensors" such as "scaling the Y scale intensity values." Ex. AG (Dagher), ¶ 78. The intensity information is just the values of the channels of data representing the pixels, not some new magical concept. Dagher is therefore wholly consistent with "image data" encompassing data representing the pixels.

160. Third, Dr. Hart argues that "it is commonly known in the art that an 'image,' even a 'digital image,' need not be a rectangular matrix of pixels or have any 'pixels' at all in any sense of the term." I disagree. In the context of the '291 patent – digital photographic imaging systems – images are made up of pixels. I will respond individually to the supposed examples Dr. Hart provides to support this statement.

161. Dr. Hart states that "In today's usage, many (or even most) digital images begin their existences as digital data in an uncompressed format, which is in most cases a standard array of colors assigning RGB values to cells in a mathematical matrix and which can be interpreted by software to display an image." Hart CC Decl. (Dkt. 148_11), ¶ 65. While Dr. Hart appears to be avoiding using the word pixel, each cell having RGB values in a mathematical matrix, as he describes, is called a pixel.

162. Dr. Hart next says that "The bitmap may be compressed with encoding with any available compression algorithm such as run-length encoding or a lossy compression algorithm just as JPEG. In such compressed formats, each element of image data does not correspond directly with each image pixel. Images in this class are called "raster" images." As an initial matter, an image is not known as a "bitmap." Typically graphics image (i.e., computer generated images) are referred to as bitmaps. So I understand him to be saying that the RGB representation of an image may be compressed into a format in which each element of image data does not correspond "directly with each image pixel." That is true that each element of image data does not correspond directly with just ***one*** image pixel. Rather, in the compressed file formats, an element of image data may correspond to the values at ***multiple*** pixels. By storing the value of a pixel only once and then identifying the other locations that value is used, the data can be compressed. But that doesn't remove such data from the scope of Apple's proposed construction. This image data is still "data representing a pixel."

163. Moreover, Dr. Hart's presentation in his CS418 Computer Graphics course shows that he too agrees that raster images are made up of pixels. https://www.sambuz.com/doc/images-ppt-presentation-899536. In this slide below from his presentation, he explains that Raster Images are 2-D Arrays of color values, i.e., they are pixels. He explains that the aspect ratio is called the "Pixel aspect ratio" and includes the color resolution in terms of bits per pixel.



https://www.sambuz.com/doc/images-ppt-presentation-899536, at 8.

164. ***Fourth***, Dr. Hart and Corephotonics argue that Apple's construction would exclude vector data. In my opinion, no POSITA would understand the term "image data" in the '291 patent to include vector data. Vector images are generated using graphics programs such as Adobe Illustrator or Microsoft Powerpoint, with a graphical user interface and are encoded using geometric primitives such as lines, disks, or polygons – they are not photographs generated by image sensors. The image data in the '291 patent is output from an imaging section with a lens, an image sensor, and an image signal processor. It is not generated by a computer using computer graphics techniques. Thus, POSITA would not think that the term image data in the '291 patent refers to vector data.

165. Corephotonics's proposed construction of "image data" is far too broad. The proposed construction is: "data output from an imaging section." The '291 patent claims have two imaging sections, a Wide imaging section and a Tele imaging section. ''291 Patent, claim 1. Each imaging section includes a lens, a sensor, and an image signal processor. According to Corephotonics's construction, "image data" can be any data output by the imaging section. The imaging section can output various types of information that are not information about the pixels representing the image. For example, each imaging section can output information such as mechanical settings, white balance gain, exposure time, analog gain, and color correction matrix. White balance gain is an aggregate measure of the amount that the colors in an image must be adjusted to achieve the correct color temperature. See, e.g., Ex. AE (*Photography*), at 98-99. Exposure time is how long of an exposure was used to capture an image. [cite] A POSITA would not be consider such information to be image data.

166. Moreover, the '291 patent explicitly states that these types of information are "secondary information," not image data. '291 Patent, 4:57-59. The '291 patent states that in video mode, its invention does not fuse the Wide and Tele images. Instead, in video mode, the patent switches between the Wide and Tele cameras, without fusion. *Id.*, 3:41-44 ("In video mode, optical zoom is achieved 'without fusion', by switching between the W and T images to shorten computational time requirements, thus enabling high video rate."). The camera switches from the Wide to the Tele when the user increases the level of zoom during video mode (i.e., goes from a low zoom factor, or ZF, to a high zoom factor). The camera switches from the Tele to the Wide when user decreases the amount of zoom in video mode, i.e., when a low ZF is used. The '291 patent further states that when switching during video mode, the video output images "are provided with a smooth transition." '291 patent, 4:46-48. The patent explains that this smooth transition when switching can use "secondary information":

> In an embodiment, the camera controller configuration to provide video output images with a smooth transition when switching between a lower ZF value and a higher ZF value or 55 vice versa includes a configuration that uses at high ZF secondary information from the Wide camera and uses at low ZF secondary information from the Tele camera. As used herein, "secondary information" refers to white

balance gain, exposure time, analog gain and color correction matrix.

'291 patent, 4:52-59. Thus, when zooming in to a higher ZF value, there is a switch from Wide camera to Tele camera, and when using the Tele camera, it may use secondary information from the Wide camera. Likewise, when zooming out to a lower ZF value, there is a switch from Tele camera to Wide camera, when using switched to the Wide camera, may use secondary information from the Tele camera.

167. If Corephotonics's construction of "image data" is correct, then the '291 patent's "secondary information" would be "image data." Then, the use of the Wide camera secondary information together with a Tele image at a high ZF (as described in the passage above) would constitute fusion. But the patent says that switching, including the use of secondary information, is "without fusion." The '291 patent is thus consistent with the understanding of a POSITA that this type of information – information that is not per pixel data values representing the image – is not "image data" in the '291 patent.

168. Finally, I note that the '291 patent relates to computational photography. See, e.g., https://corephotonics.com/patents/ (Corephotonics' website listing the '291 patent under its list of "Dual camera imaging algorithms" patents."). One of my research focuses is computational photography. *See* http://people.csail.mit.edu/fredo/ (describing an overview of my work in computational photography)

169. Dr. Hart's CV shows his work focuses on computer graphics. *See also* https://cs.illinois.edu/about/people/faculty/jch (describing Dr. Hart's work in "computer graphics," that he is the "graphics area editor" for ACM Books, and teaches a course in computer graphics); https://www.linkedin.com/in/johnchart/ ("I research and teach a wide variety of topics in computer graphics … ."). While the term image data may have some meaning in computer graphics and vector graphics (of which Dr. Hart has provided no examples), that meaning is not applicable to the context of the '291 patent or how a POSITA in imaging systems would understand the '291 patent.

I declare under penalty of perjury that the foregoing is true and correct to be best of my knowledge.

Executed on October 13, 2022 at Somerville, MA.

Fredo Durand

Frédo Durand

Frédo Durand

Professional Preparation

École Normale Superieure of Paris	Bachelor (math and computer science)	1993
INPG, Grenoble, France	MS (computer science)	1994
Université J. Fourier, France	PhD (Computer Science)	1999

Appointments

Massachusetts Institute of Technology	Professor of EECS	Jul. 2012 – present
Massachusetts Institute of Technology	Associate Professor of EECS	Jul. 2006 – 2012
Massachusetts Institute of Technology	Assistant Professor of EECS	Sep. 2002 – 2006
Massachusetts Institute of Technology	Post-doctoral fellow	Sep. 1999-Sep. 2002
Université J. Fourier, France	Teaching assistant	Sep. 1997-Sep. 1999

Conference organization: Co-organizer and paper co-chair of the first IEEE International Conference on Computational Photography.
Co-organizer (with Marc Levoy and Rick Szeliski) of the 2005 Symposium on Computational Photography and Video, Member of the advisory board of Image and Meaning 2, an interdisciplinary conference on scientific illustration and education

Program Committees and Editorial Boards: ACM SIGGRAPH, Eurographics Symp. on Rendering, Graphics Interface, Eurographics, NPAR, Symposium on Point-Based Rendering, ACM Transactions on Graphics, Foundations and Trends in Computer Graphics and Computer Vision.

Awards

Eurographics Young Researcher Award 2004
NSF CAREER award 2005
Microsoft Research New Faculty Fellowship 2005
Sloan fellowship 2006
Spira award for distinguished teaching 2007
MIT Faculty Research and Innovation Fellowship 2012
Eurographics fellow 2014
ACM SIGGRAPH Computer Graphics Achievement Award 2016
ACM fellow 2016
ACM Siggraph Academy 2018

Publications

1. **Chapters in Books**

   1 Chan, Eric and Frédo Durand. Fast Prefiltered Lines. Chapter in GPU Gems II edited by Matt Pharr, Addison-Wesley Professional, March 2005 **

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4. **Other Major Publications**

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8. Ngan, Addy, Frédo Durand, Wojciech Matusik, "Experimental Validation of Analytical BRDF Models," Technical Sketch, SIGGRAPH 2004, (1 page), Los Angeles, California, August 2004. **

PATENTS:

1. Image-Based Modeling And Photo Editing
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